Proceedings of the
CIB W096 ARCHITECTURAL MANAGEMENT

Publication no. 307

‘SPECIAL MEETING’ on
DESIGNING VALUE:
NEW DIRECTIONS IN ARCHITECTURAL MANAGEMENT

TECHNICAL UNIVERSITY OF DENMARK,
LYNGBY, DENMARK
2, 3 & 4 NOVEMBER 2005

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Organised by

Section for Planning and Management of Building Processes
Department of Civil Engineering
Technical University of Denmark

Design Management Group
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Delft University of Technology

ISBN 87-7877-190-0

INTERNATIONAL COUNCIL FOR RESEARCH AND INNOVATION IN BUILDING AND CONSTRUCTION

Purpose, Scope and Objectives

The purpose of CIB is to provide a global network for international exchange and cooperation in research and innovation in building and construction in support of an improved building process and of improved performance of the built environment.

The scope of CIB covers the technical, economic, environmental, organizational and other aspects of the built environment during all stages of its life cycle, addressing all steps in the process of basic and applied research, documentation and transfer of the research results, and the implementation and actual application of them.

The objectives of CIB are to be: a relevant source of information concerning research and innovation worldwide in the field of building and construction; a reliable and effective access point to the global research community; and a forum for achieving a meaningful exchange between the entire spectrum of building and construction interests and the global research community.

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Each Task Group and Working Commission consists of individual experts in the respective area who meet annually, cooperate in voluntary international research projects, produce state-of-the-art publications and organise global conferences

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TG33 Collaborative Engineering
TG42 Performance Criteria of Buildings for Health and Comfort
TG43 Megacities
TG44 Performance Evaluation of Buildings with Response Control Devices
TG49 Architectural Engineering
TG50 Tall Buildings
TG51 Usability of Workplaces
TG52 Transport and the Built Environment
TG53 Postgraduate Studies in Building and Construction
TG55 Smart and Sustainable Built Environments
TG56 Macroeconomics for Construction
TG57 Industrialisation in Construction
TG58 Clients and Construction Innovation
TG59 People in Construction
TG60 Critical Infrastructure Protection

Working Commissions
W014 Fire
W018 Timber Structures
W023 Wall Structures
W040 Heat and Moisture Transfer in Buildings
W051 Acoustics
W055 Building Economics
W056 Sandwich Panels (joint CIB - ECCS Commission)
W060 Performance Concept in Building
W062 Water Supply and Drainage
W065 Organisation and Management of Construction
W069 Housing Sociology
W070 Facilities Management and Maintenance
W077 Indoor Climate
W078 Information Technology for Construction
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- Newsletters and News articles
- Databases

Newsletters and News Articles

In this section hundreds electronic copies are included of the various issues of INFORMATION, the CIB Bi-Monthly Newsletter, as published over the last couple of years and of incorporated separate recent news articles. Also included is an Index to, facilitate searching articles on certain topics published in all included issues of Information.

Databases

This is the largest section in the CIB home page. It includes fact sheets in separate on-line regularly updated databases, with detailed searchable information as concerns:

- ± 400 CIB Member Organizations, including among others: descriptions of their Fields of Activities, contact information and links with their Websites
- ± 5000 Individual Contacts, with an indication of their Fields of Expertise, photo and contact information
- ± 60 CIB Task Groups and Working Commissions, with a listing of their Coordinators and Members, Scope and Objectives, Work Programme and Planned Outputs, Publications produced so far, and Schedule of Meetings
- ± 100 Publications, originating to date from the CIB Task Groups and Working Commissions, with a listing of their contents, price and information on how to order

- ± 250 Meetings, including an indication of subjects, type of Meeting, dates and location, contact information and links with designated websites for all CIB Meetings (± 50 each year) and all other international workshops, symposia, conferences, etc. of potential relevance for people interested in research and innovation in the area of building and construction.

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PREFACE

The International Council for Building Research and Innovation in Building and Construction (CIB) was established in 1953 and has since developed into a worldwide network of over 5000 experts from about 5000 member organisations. These members are active in the research community, in industry and in education, who cooperate and exchange information in over 50 CIB Commissions covering all fields in building and construction related research and innovation. The purpose of CIB is to provide a global network for international exchange and cooperation in research and innovation in building and construction in support of an improved building process and of improved performance of the built environment.

Although the term architectural management has been used since the 1960s it was not until 1992 that the CIB working group W096 Architectural Management was formed. Since this time the Commission has been particularly active in the area, with regular conferences, meetings and published conference proceedings. At the CIB World Congress in Toronto in April 2004 a decision was taken to arrange a 'Special Meeting' of W096 to look back at what has been achieved since the formation of W096, assess the current situation and (most importantly) look to the future. In addition to this book of proceedings CIB W096 will be publishing a new book that sets out key objectives for future research and practice in the field of architectural management. The book will be comprised of themed chapters written by participants at the Denmark meeting and edited by Stephen Emmitt and Matthijs Prins.

Researchers were invited to address the following topics:

- Valuing Design

Re-valuing architecture; defining architectural value; the role of architects, engineers and other designers in re-valuing construction activities; design and measuring architectural value; balancing customer needs and environmental concerns; a whole life approach, …

- Communicating Design

Effective briefing, design quality; information and knowledge management; inter-personal communication and decision-making; communicating design intent; embedding architectural values; designing and managing project networks; …

- Inclusive Design

Client empowerment; capturing the requirements of all users; stakeholder values; designing for disability; health and safety; establishing value parameters; environmental parameters; project and organisational culture; creative clusters; harnessing innovation; integrated project teams, …

- Design Management

Identification of appropriate strategies and tools; the role of the design manager; appropriate managerial frameworks for creative activities; hard and soft approaches; performance-based approaches; innovative practices; leaner and greener methods; risk management; process and value management; …

- Design Integration

Total design approaches; the lean philosophy applied to architectural design management; design for manufacturability; constructability and disassembly; co-ordination issues; roles and positions; interface between design and production; TQM; feedback and POE, …

- Design Management Education

Developments in architectural management education; education as an agent of change; integration of management into design education; the role of Masters and PhD research programmes; life-long learning; competence development; …

- Revaluing Architectural Practice

Redefining 'architectural practice'; developing a collaborative culture; office culture; knowledge transfer between projects; working environment; outsourcing; marketing; …

From our call for participation we received a total of 81 abstracts. These were reviewed and the successful authors were invited to submit full papers. Each paper was subjected to a rigorous double blind refereeing process after which authors submitted revised papers. These papers were further edited to ensure a degree of consistency to the proceedings, however it should be noted that the views expressed are those of the paper authors. The result of the review process is a total of 46 papers submitted by authors from around the globe. Authors include doctoral students, academics and practitioners. Collectively the papers provide a fascinating insight into the world of architectural management. These papers have been grouped under six key themed headings for the purposes of the proceedings.

The event was organised by the coordinators of CIB W096, Professor Stephen Emmitt of the Technical University of Denmark and Dr. Matthijs Prins of Delft Technical University. We would like to thank the members of the scientific review committee and the conference secretary Kirsten Gammelgaard for their help in ensuring a successful conference.

Stephen Emmitt and Matthijs Prins

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VALUING DESIGN

VALUE CONCEPTS AND VALUE BASED COLLABORATION IN BUILDING PROJECTS

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Abstract
Value has in recent years become a popular term in management theory and practice in general as well as in economic theory and architectural management. This paper attempts to clarify the various uses and meanings of concepts of value/values. Six different value concepts are identified. The origin and use of value concepts in classic and modern economic theory and in management theory is outlined. The question of objectivity and subjectivity is discussed in relation to economic value and customer value. Value creation is put in relation to development in products and processes and a number of design strategies are identified. The concept and methods of value based management and collaboration is discussed in this context. The paper is mainly theoretical and based on a MBA study as well as many years of experience as building client and facilities manager.

Keywords: Design strategies, performance, value creation, value management, value-based collaboration.

THE CONCEPTS OF VALUE(S)

Value as a concept has many different meanings and usages. There is a basic difference between value in the singular, expressing the worth of something, and values in plural, which has relation to personal belief and social behavior. Based on literature studies the following categories of value have been established (Graeber, 2001, Harpe, 2005, Hatch, 1997, Jensen, 2003, Pine & Gilmore and Thyssen, 2002):

1. Religious values – Values as belief system (not dealt with in this paper)
2. Behavioral values – Values as moral and ethics
3. Economic value – Value as exchange
4. Use value – Value as utility
5. Cultural value – Value as meaning and sign
6. Perception value – Value as experience

Exchange and use value was at the center of thinking concerning value in classic economic theory in the 19th century. In neo-classic economic theory, the theory of value of labour from the classic economical theory was neglected and value did not have a central role as a theoretical concept (Andersen & Keiding, 1997). In recent economic theory the concept of value has however got a renaissance, not least as the concept of Economic Value Added (EVA), which clearly relates to exchange. Exchange value is in general the starting point for most economic thinking. Furthermore, the concept of value has become increasingly popular in some of the literature on management, especially within strategy and marketing. Among the most well known is Porter’s theories on value chains, which like most economic theory relates to exchange value (Porter, 1985). Another example is the strategy thinking of Teece concerning ”non-tradeable assets” like knowledge, innovative capabilities, brands and service concepts, which relate to use value (Teece, 2003).

Within product development and design use value is also the natural starting point, although often in a combination with the exchange value and value as meaning and sign. The most interesting in this context is however the relations between exchange and use value. Essential concepts in this relation are value creation and added value. In relation to a production process, value creation is defined as the value of the product reduced by the value of the resources used during the production of the product. The value of the product consists of the value of the resources and the added value. In classic and neo-classic economic theory the value of the product is on average equivalent to the price of the product. In modern marketing oriented theory there is a strong tendency to make value a completely subjectively defined concept. According to some authors product value equals customer value. It is the individual needs of the customer that define the value of the product. Similar products thus can have different value for different customers even though they may have to pay the same price for the products. There are even some authors, who claim that the value creation of a product is dependent on the products participation in the customers own value creation. Value is in these theories created jointly (co-produced value) between deliverer and customer (Ramírez & Wallin, 2000).

The apparent contradiction between objective and subjective definitions of value could be resolved using the definition of economic value formulated by Cook (1997). Opposite to the general understanding in economic theory that price is an expression of value, Cook’s argument is that a product to be produced must have a value that exceeds it’s price. The difference between the price and the production cost makes up the producer’s ”free value” or ”net value”. The difference between the value and the price makes up the buyer’s free or net value. Hence, both the producer and the buyer gain from the transaction. It is remarkable that this understanding of value closely follows the understanding of value in the classic economic theory and at the same time is coherent with the fundamental market mechanism. In the theory of labour value, the basis for value creation is that labour creates more value than the cost of labour. The value of labour exceeds the price of labour. Why should this only apply to labour and not to all products? This means that the added value is redistributed to all products mediated by the market mechanism. The added value will be distributed between producers and buyers according to the relative power of supply and demand. In relation to partnering in the building process, it is of particular interest that the fundamental transaction of exchange with this understanding is a ”win-win” situation, which also is a basic aim in partnering.

Based on Cook’s understanding the product value can be divided in a relatively objective use value or design value and a more subjective customer value. The design value is under market conditions expressed by the exchange value, while customer value is decisive on how the demand for potential customers is divided on competing products. In a marketing context, it is therefore important to develop a design value that is increasingly more segmented and adapted to specific groups of customers to attract a higher proportion of the potential demand – or a more exclusive part willing to pay a higher price.

There is in general a definite tendency in marketing to ”undermine” the market relations by creating closer and longer lasting relations between deliverers and customers. In this way the market related transaction costs could be reduced for both deliverer and customer, leading to reduced usage of resources and increased value creation. According to Ford et al (2002) a customer can gain value in two ways: The value of the offering and the value of the relationship. The building industry has traditionally focused solely on the value of the offering. It may be time for the industry also to gain value from relationships.

VALUE AND PERFORMANCE

A researcher from Finland refers to the four e’s of performance: “Performance is a factor of the building feasibility. The four e's of performance are economy, efficiency, effectiveness and efficacy”... “Economy means doing things for low cost”....”Efficiency is doing things right, i.e. using resources well. Effectiveness is doing the right things; it is taking into account the market demand. Efficacy means the relevance of the outcome.” (Himanen, 2003). These concepts of performance can be divided in relation to the exchange and use value and the distinction between process and product as shown in figure 1. The performance concepts can be regarded as different methods of creating value.

Figure 1. Different methods for value creation

	Exchange value	**Use value**
Process	Economize	Efficiency
Product	Effectiveness	Efficacy

The method of economization aims at lower production cost per unit by acquiring cheaper resources or making the workforce work harder without an equivalent increase in salaries. The efficiency method aims at increasing output without increasing the use of resources by working smarter and doing things right the first time. The effectiveness method aims at the highest possible income from sales by doing the right things in relation to the demand from the market. The efficacy method aims at increasing the products fulfillment of need and user satisfaction.

The above methods mostly apply to production of goods. In delivery of services and experience the process and product aspects melt together and cannot be analyzed separately. According to Pine & Gilmore (1999) a general increase in value occurs as society develops from agriculture, to industry, to service and further on to experience and ultimately to a so-called transformation society.

An important aspect of use value creation is that business processes can both create value for the customer and internally in the production process, for instance in the form of new knowledge and other “non-tradeable” assets as mentioned earlier. This is becoming increasingly important, which the many efforts to create learning organizations illustrate. Speculative capital investments can be seen as a parallel in creation of exchange value

(Sarasoja et al, 2004). Both non-tradeable assets and speculative capital investments are capabilities that aim at long term benefits. Value creation can also take place in relation to cultural value and perception value. Cultural value includes branding and the image of companies as well as prestige and signal value for individual customers. Perception value relates to the customers experience by use of a product or participating in an event.

VALUE BASED MANAGEMENT AND COLLABORATION

A Danish working party on value management has produced a State-of-the-Art report, where the value aspect of the productivity concept is in focus. A distinction is made between an external set of values, which is defined as the customer value regarding both product and process and an internal set of values defined as the value based behavior in the delivery team (Christoffersen, 2003). Compared with the earlier defined categories the external set of values can relate to exchange, use, cultural and perception value, while the internal set values relate to behavioral value. The external set of values are equivalent to the values which are defined by use of value management in the way the term is used in building literature in the UK (Blyth & Worthington, 2001, Green, 1996 and Kelly & Male, 1993) and in the international literature on lean construction (for instance Koskela, 2000). Other authors use the concept value management equivalent to value based behavior and value based management. Thyssen (2002) sees values in an ethical and moral context and also makes a close link between the value base and the strategy of an organization. A value base must be developed in dialogue as part of a political process.

In relation to partnering it seems relevant to make a distinction between value based management and value based collaboration. Value based management is managing an organization based on values defined by the management, i.e. management values. Value based collaboration is a collaboration between different organizations based on values defined by the collaborating parties, i.e. collaboration values. Value based collaboration will or can include a value management process of defining the external set of values together with the end users of the building project.

A test building project of a student hostel called Limfjordskollegiet in Aalborg, Denmark had value based management as a starting point, but as the project developed the involved parties changed the terminology towards value based collaboration (Wandahl, 2002). Values were originally defined in a workshop using the concept of “future workshop” as a methodology. Starting from not preferable “anti-values” the involved parties defined the preferred values in the project collaboration, and this led to the definition of a value base included in a formal agreement of collaboration.

During the project period the values were monitored every fortnight by use of an IT-based value-web, where all parties should give their evaluation of the importance and the fulfillment of the different values by indicating a score between 1 and 5. At meetings and workshops the evaluations were discussed and actions agreed upon.

In a major on-going Danish building project - DR BYEN - the project management of the client organization is utilizing value based management, and the collaboration with consulting companies and contractors is based on partnering. DR BYEN is a multimedia building which is to be the new headquarters for DR (Danish Broadcasting Corporation) in Copenhagen. The project includes a total of 130.000 sq. m divided in four segments, with different teams of designers and contractors for each segment. The author was employed as deputy project director in the client organization until spring 2005.

A value base for managing the client organization in DR BYEN was defined by the project management. This was developed during seminars involving the leading members of the clients project management organization. Similarly, the collaboration parties have as part of the partnering process defined common vision, objectives and rules for the collaboration. The example used in this paper concerned segment 3 and was developed at the beginning of the design development at a kick-off seminar with representatives from the design team and the client. The outcome was called rules of collaboration, but they are very close to the values defined at Limfjordskollegiet and the partnering collaboration can be regarded as value based collaboration. A comparison of the value base of DR BYEN's project management and the values in the collaboration in both Limfjordskollegiet and DR BYEN's segment 3 is shown in Figure 2.

Figure 2. Comparison of the values of collaboration (from Jensen, 2003).

Values on collaboration in Limfjordskollegiet	**Values of management in DR BYEN**	**Rules of collaboration in DR BYEN's segment 3**
Good collaboration	Good partner of collaboration	Collaboration should be a gain for all
Honesty and openness	Honesty + openness	Open and honest
Respect and equality	Respect for others	Respect
Keeping agreements	Timeliness	Timeliness
Joint responsibility	Professionalism	Holistic
Effective communication	Dialogue	Dialogue
Sharing of knowledge		Helpfulness
It must be good fun		Be good fun
		Self-realization
		Clear to everybody

The comparison shows a lot of similar values and rules for managing and collaborating. The main difference is that the value base for DR BYEN's value based project management does not include values related to personal engagement and personal gain in relation to knowledge sharing, self-realization and enjoyment, which are present in both cases of value based collaboration. The value based management mainly focuses on the values of the organization as a company, while the value based collaboration also put focus on the individual aspects of the collaboration.

This clearly indicates that it makes a difference to define collaboration values in a group based process with all involved parties. The participants start to realize their possible individual gain from the process instead of just seeing themselves as professionals representing their company.

CONCLUSION

Based on the above mentioned methods of value creation and management of value, a set of different strategies for value creation has been identified as shown in Figure 3.

A focus on value creation has the advantage that it at the same time requires a holistic approach and awareness towards what is essential for the company and it's customers. Cook (1997) expresses it as follows: "Understanding how value is generated is vital to the development of successful products because value is the only fundamental metric which makes a positive contribution to all the other bottom-line metrics". The difficulty with the concept of value is the many different facets and aspects, and a lack of agreement on the definition and practical application of the concept.

This paper shows from a theoretical point of view, that the concept of value and value creation should be related to both producers and customers as well as to both processes and products. There is however a clear trend towards increased collaboration between producers and customers in value creation. This applies to business in general as well as to the building and facilities management industries. Another trend is that products and processes are becoming more and more intertwined, particularly in the expanding areas of delivering services and experiences. This trend is one of the driving forces behind the development of facilities management as a service delivery.

Both trends are also important for the building industry. The increasing demand for involvement of the end users in the building process is an example of collaboration between producers and customers in the value creation process. However, it is also an example of the increasing need for delivering services and experiences to the customer during the process as part of the products delivered by the building industry.

The paper also indicates that the practical implementation of value management in the form of value based collaboration can provide a holistic approach to building process development and building product evaluation that is promising in relation to the positive engagement of all stakeholders in the building process and providing a more holistic product assessment compared to other methods for building evaluation.

Figure 3. Strategies for value creation

	Behavioural values	Exchange Value	Use value	Cultural value	Perception Value
Process	Value based management.	Minimize cost of resources. Maximize output with the same resources.	Gradually improve process by doing things right. Radically improve process by working smarter. Improve process to create new internal knowledge.		
Product		Maximize amount of sales by doing the right things. Maximize product prizes. Speculative capital Investments.	Gradually improve product by increased functionality. Radically improve product by new functionalities.	Create significant products that support company branding and customers signal value.	Create products that give customers valuable experiences.
Process and Product			Make the process part of the product by including services of value for the customer.		Create events that give customers valuable experiences.
	Value based collaboration.				

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ARCHITECTURAL DESIGN IN THE CONSTRUCTION VALUE CHAIN

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Abstract
Productivity in architectural consulting is under discussion owing to the fact that the traditional Design/Bid/Build contracting is being replaced by CM. ICT's positive impact on planning efficiency is considered self-evident, but reliable evidence is hard to find. Some findings indicate even a contrary development. Additionally, as opposed to manufacturing, external and internal efficiencies overlap when providing service. In manufacturing, R&D has been seen as a support activity whereas manufacturers like Nokia have identified R&D as a key activity and added value. In modern construction the providing of working drawings seems to be getting closer to the providing of service. Moreover, in A/E consulting economies of scope create cross-business cost-saving opportunities, whereas economies of scale may benefit process engineering. The objective is to understand how architectural designing can be molded into a strategic fit in the construction value chain. In the main, the solution is seen in the development of new tools. This article evaluates the influence of the strategic variation of the value chain activities throughout the project. The methodology is divided into a theoretical part, statistical data, and retrospective analysis in HUT's research project "Developing a Design System for CM contracts". It may be less fruitful for the stakeholders to develop totally new methods as opposed to simply improving one's understanding and carefully tuning the existing processes. For example, knowledge management should be the driver in the preliminary design, manufacturing productivity in the conceptual designing phase, and the productivity of service management in the working drawing (construction) phase.

Keywords: A/E consulting productivity, construction value chain, economies of scope, CM contracting, service management.

INTRODUCTION
Simply put, despite progress made in the preliminary phase the doing is clear, but the objective is often in chaos, i.e. from the point of view of implementation. Conversely, in the construction stage the doing is often in chaos, but the objective is clear. The term "doing" refers to planning, coordination, procurement etc. as a whole. Since the invasion of Information and Communication Technology (ICT) in the early 90's, its positive impact on architect and engineer (A/E) consulting productivity is considered self-evident. However, most ICT research projects seem to focus on 3D and 4D modelling, while reliable data on the impact of two-dimensional ICT is harder to find (Georgy et al 2005). Some findings actually indicate even a contrary development. In architectural consulting managing change is an issue from both the business and the process viewpoint. From the business viewpoint, actions by the authorities such as deregulation may have even distorted market equilibrium. A better understanding of what drives the A/E industry's demand and supply might put the industry in better balance in the long run (Raveala 2005). From the viewpoint of the process, bearing in mind that traditionally procurement packages have been the drivers of project management, also the processes are changing e.g. owing to the fact that Construction Management (CM) is replacing Design/Bid/Build

(DBB) contracting, and increasing the complexity of project and design management, coordination of responsibilities etc. The CM level of influence is attributable to the greater number of the procurement packages (the hatched area in Figure 1). The increased complexity particularly from the viewpoint of construction value chain forms the framework of this article (Figure 2). The scope the construction value chain activities are broadening both in number and strategically. The influence on architectural consulting, which is a support activity, varies from project to project and from phase to phase. This paper focuses on three phases of architectural design: (1) the preliminary phase, (2) the conceptual design, and (3) the working drawings (Kiiras 2005; Raveala 2005).

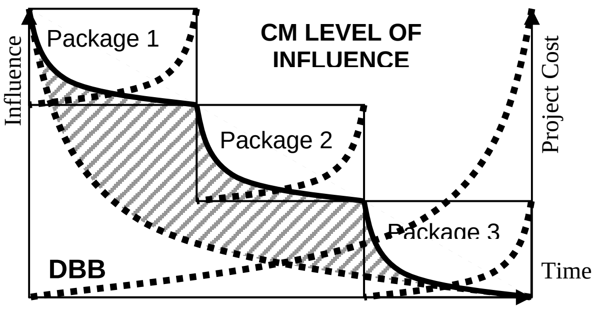

Figure 1: Influence in CM projects vs. DBB

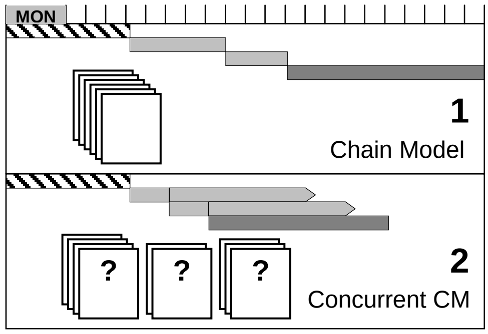

Figure 2: Des. Management in CM

OBJECTIVES

From the designer’s point of view, in modern contracting target setting varies in any given planning phase. The objective is to understand through these differences how architectural designing can be managed as a strategic fit in the construction value chain and how to carefully tune the existing processes, which may benefit the designers and constructors more than merely developing totally new methods. Several models for improving efficiency and better resource allocation are developed, but standards and tools don’t usually reach a generally accepted level. In addition, the question whether A/E consulting is demand or supply driven is a valid question in the long run. It seems that the competition authorities have seen the consulting fee as a main driver, but e.g. deregulations haven’t fulfilled the expectations. Nevertheless, this article focuses on what drives the designing process and how the process should be managed.

Productivity and Efficiency

Service management identifies two efficiency dimensions (Grönroos 2000). The first, internal efficiency, could be defined as a firm’s return on capital or labor. External efficiency, on the other hand refers to the customer’s perception of the output. In traditional manufacturing the client simply receives the output, whereas in the service sector the client is involved in the production process. Particularly in CM projects, the providing of working drawings seems to be getting closer to the providing of service. One objective is to evaluate how service management can improve output as a whole. Table 1 shows how the ratio of number of the hours produced in architectural consulting to the number of hours produced in construction sites has remained stable since the year 1987 (Pulkkinen 2001; Statistics Finland 2004) on the level of approximately 15 architectural consulting hours to one thousand construction output hours. The data shows also the proportional growth of renovations in the recession between 1991 and 2000, and also the estimated non-paid share of the architects' output spent on architectural competitions. The figures cover both newbuilding and renovations. The figures imply that so far ICT has created very little, if any, additional value for the designers. Nonetheless, if it created value added, the question is to whom?

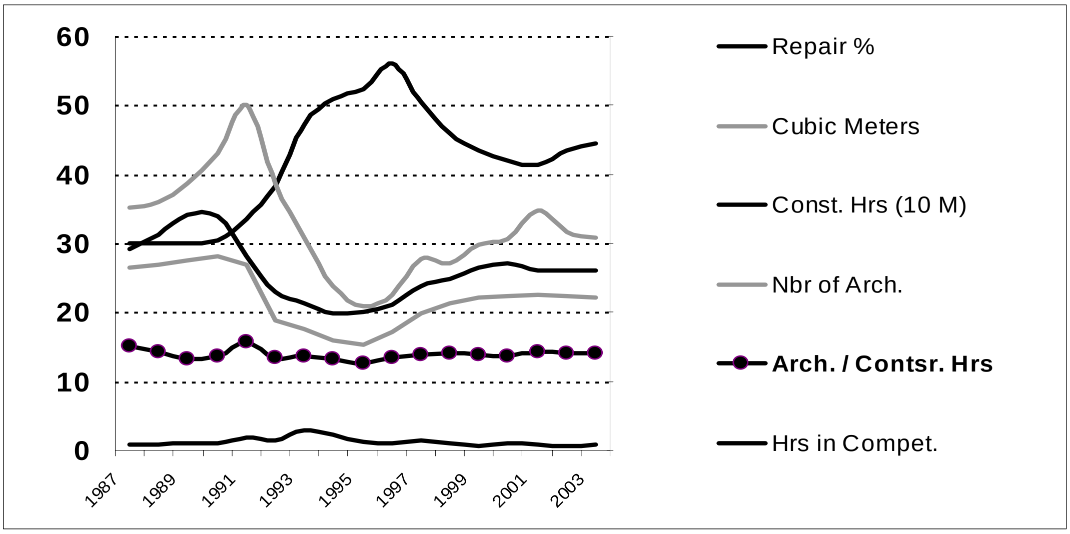

Table 1: The ratio of produced architects' hour to produced construction (site) hour

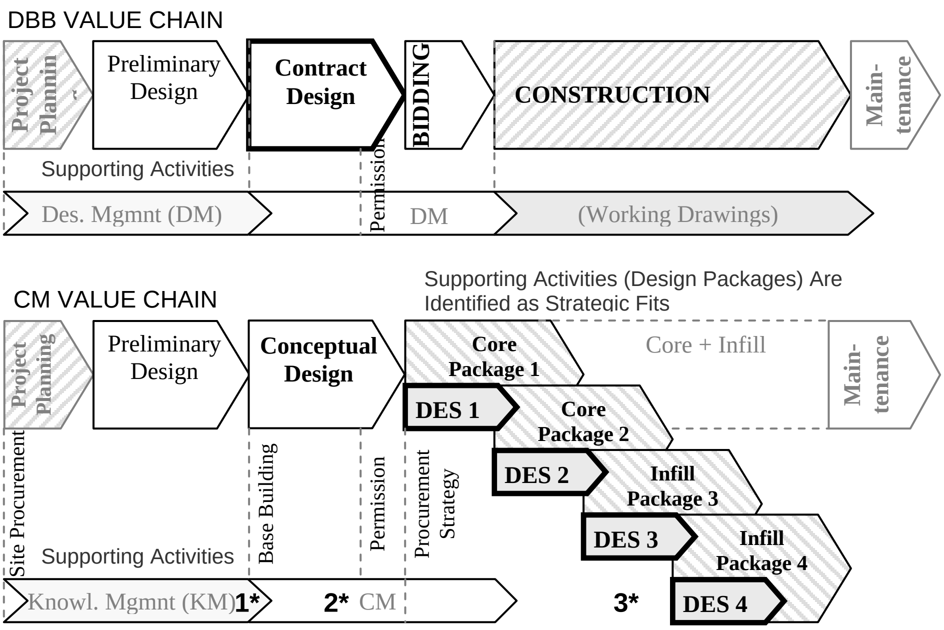

Figure 3: Construction Value Chain in CM and DBB (DES = Design Package)

Strategic Value Chain in Economics

Value chain thinking involves identifying a firm's value adding and support activities (Thompson et al 2003). In manufacturing, the value chains of rivals may differ in degree of vertical integration. In manufacturing, R&D is seen as a support activity, whereas manufacturers like Nokia have added value by identifying R&D as a key activity. In construction, the increase of CM contracting broadens the scope of activities. Thus, the role of A/E consulting in the value chain has to be revised. The suggested cost management stages in the CM value chain are (1*) setting the target cost in the preliminary stage, (2*) checking the total cost (3*), and checking the total cost, package by package. The DBB and CM value chains are illustrated in Figure 3.

When assessing a firm's competitiveness a manager has to understand the entire, not just the firm's own, value chain, and the product's total life cycle cost (LCC). To the end user the last activity in the value chain is the maintenance and integration of the facility management process. The facility management planning should overlap the designing activity even though the designers seldom assess the performance of the buildings they have been responsible for. This poor feedback is still a major burden and the standardizing of the maintenance tools is still under way (Bröchner 2003).

METHODOLOGY

Methodology

The methodology is divided into three categories: statistical analysis, comparable case analysis (peer groups), and comparable method analysis (theories). The article is a part of the research project "Developing a Design System for CM contracts" of the Construction Economics and Management (CEM) unit of Helsinki University of Technology (HUT) (Kiiras 2005). The project involves approx. 30 national retrospective case analyses, and an ongoing prospective testing of the suggested model (FinSUKE). The method analyses are based on the Management Cost Accounting and Strategic Value Chain applications and theories. The data for the case analyses is collected through questionnaires and additional interviews. The statistical data is provided by ATL, the Association of Finnish Architects' Offices; SKOL, the Finnish Association of Consulting, Statistics Finland, and international professional journals.

Accuracy

The data on newbuilding is more accurate than that on renovation, which is obtained from various sources. However, because newbuilding and renovation cannot be separated form the hours produced in architectural consulting, the total hours produced at construction sites is used for the output of the construction work. Despite the fact that the accuracy may vary, the correlations are valid. The data doesn't cover the grey market or the growth in employee leasing. The latest estimations of their share vary from 4,000 to 10,000 employees, with a 3 to 6 % maximum deviation.

RESULTS

The Primary Findings

A manufacturing value chain differs from a service sector value chain (Thompson et al 2003). The three i.e. preliminary, conceptual, and construction phases differ on the basis of their drivers and cost management. In the conceptual phase, the designers influence the quality and the total cost of the project through the product, mainly the fixed base building (support, shell, and core). In the construction phase, by contrast, the designers influence the quality and the total cost through the process e.g. the procurement strategy and the implementation of the space infill.

Table 1 shows that the output in architectural consulting in Finland between the years 1987 and 2003 did not improve much, if at all, as the invasion of ICT and lean construction (Pulkkinen 2001; Statistics Finland 2004) would suggest. Any possible value added gains may have accrued to the benefit of others e.g. the contractor and/or the investor. Although the construction sector has yielded growing profits in the last few years, possible value added gains and, on the other hand, the strong macroeconomic growth, are difficult to distinguish from the overall profits. It seems that the users and the real estate proprietors have been beneficiaries of these trends.

In traditional manufacturing economies of scale can be achieved, whereas in the service sector profitability may decline after a certain point vis-à-vis production growth (Grönroos 2005). Service managers may believe that clients won't pay for improvements in service quality as has been the case in telecommunications. Traditional DBB clients are seldom interested in high productivity consulting services. Service management is a strategic fit with the construction phase, but the findings don't support economies of scale for any of the design phases. Conversely, in A/E consulting economies of scope create cross-business cost-saving opportunities in the form of sharing facilities, sources, and technologies, whereas economies of scale may benefit process engineering. In traditional manufacturing the push and pull technique (Figure 5) has been identified in the work flow management (Ballard 1999) i.e. "pulling" referring to the site "crying out" for the design documents and "pushing" referring to designers submitting the design documents in accordance with the design schedule. The analysis implies that neither model works efficiently on its own.

Preliminary Designing: Programming (Briefing) Phase

Understanding the driver of the preliminary design is the most challenging of the three designing phases. Target costing, which begins with the determination of the target selling price, would serve the client. However, linking the preliminary ideas and sketches to the project so that they support the agreed aesthetic, information, and utility values is extremely difficult. The evaluation of the preliminary design output is problematic, which is also related to the difficulties in selecting a designer. The number of articles and arguments on designer selection reveals the complexity of combining immaterial ideas with those of quality and cost issues. Moreover the evidence indicates strongly that the conceptual phase tends to unduly truncate the time scheduled for the needed preliminary design.

Knowledge management provides a promising model for linking these issues. The information collected among stakeholders is translated usually into an abstract form. To become tested, it must "re-materialize" in a form that stakeholders can deal with. In the architectural designing process this could be a loop-like iteration between briefing and sketching. The loop-like iterations (Overgaard 2004) are repeated, breaking the division between briefing and sketching, and there, create "asset value" in the form of knowledge assets (Figure 4). In this way the preliminary phase iterations and briefing are essential because they frame the knowledge assets of the project.

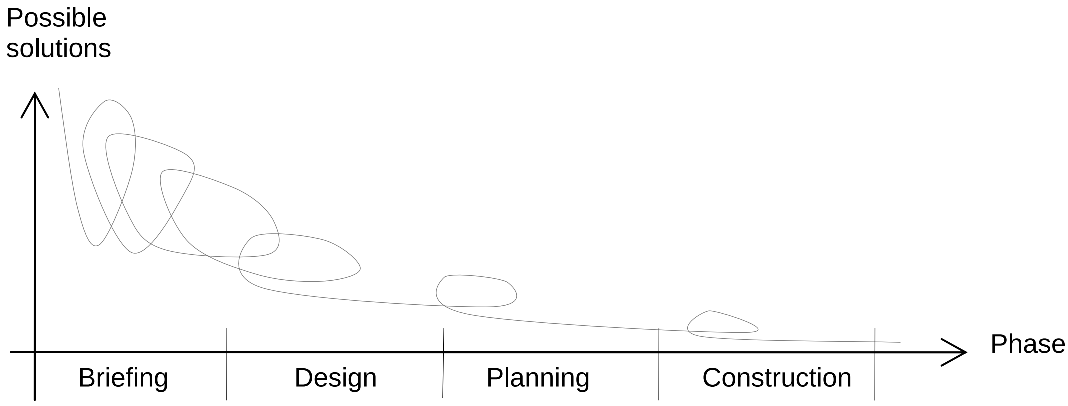

Figure 4: Iteration in different phases of construction projects (Overgaard 2004)

Conceptual Designing: Preconstruction Phase

The conceptual phase (planning in Figure 4), beginning after the knowledge management iteration, is the most product-orientated phase in the CM process and obviously the most "manufacturing productivity" driven. The conceptual design "incorporates" the principle of open building by dividing the project into the base building (support, shell and core) and into the flexible space infill. This clear distinction is a key factor for managing the overlapping activities efficiently. Target costing (TC) is applied during the design stage, whereas kaizen costing is applied during the manufacturing stage of the product life cycle (Drury 2000). In target costing a set of techniques or procedures is automatically applied to achieve cost reductions: the focus is on the product, and cost reductions are achieved primarily through design. The activity-based management (ABM) identifies non-value adding activities such as inspecting and storing, that the client is not expected to pay for. These activities can be cost effective (e.g. JIT) without reducing the value to the client.

Working Drawings: Construction Phase

The service management productivity should be the driver in the working drawing (construction documents) phase. In contrast to target costing, kaizen costing focuses on processes, and cost reductions are derived primarily through the increased efficiency of the production process (Drury 2000). A major feature of kaizen costing is that of the workers being given the responsibility for improving the processes. The value adding procedures are not automatic. Kaizen costing was developed for the Japanese automobile industry and the analogies have to be adapted when applied to construction.

The integration must be seen in a wider perspective including that of close cooperation with the tenderers of the various procurement packages. The architect has to define beforehand the procurement packages that are of aesthetical importance. If a lower level of design completion is applied, the aesthetical responsibility must be delegated to the architect and the technical responsibility delegated to the supplier (tenderer). This method has been successfully tested in the model proposed by Kiiras (2005).

CONCLUSIONS

General solutions

From the designers' point of view, rational designing packages cannot be derived efficiently from traditional bidding packages. Neither can an effective designing schedule be derived from a procurement schedule or vice versa. In the suggested model (Kruus et al 2005), design packages form rational design entities for design decision-making, pushed by designers, and bid packages for procurement decision-making, pulled by the site management (Figure 5). During the preliminary and conceptual phases, designers' pushing is the primary driver. When the base building is fixed and the agreed design packages are approved, the construction site is pulling i.e. the agreed procurement strategy drives the working drawings and the implementation phase.

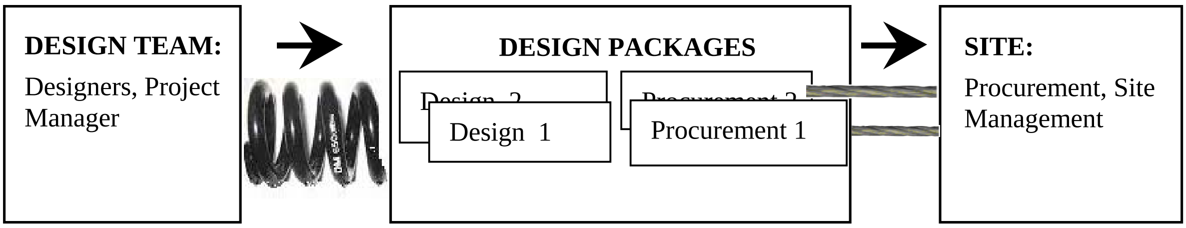

Figure 5: Design Management as a combination of Push and Pull techniques (Kruus et al 2005)

Applications

In the preliminary design phase the range of the applicable solutions is analyzed for further decision-making and choices. The leading theories of knowledge assets can improve the design procedure for the preliminary phase. The case analyses show that the time scheduled for the preliminary phase tends to be too short. An easy improvement would be just the scheduling of more time for the preliminary design, with the application pf knowledge management for instance in the adding of cycles (Figure 4) i.e. encouraging the parties to discuss the project. In addition to the latest 3D and 4D models, human-computer interaction algorithms for recognizing human sketching are being developed (Sezking et al 2001), but so far they haven't reached an applicable level that would truly increase efficiency.

The beginning phase is defined as the "preliminary phase" instead of "sketching", which is a designing tool used in all designing phases. Central to the aim of the conceptual designing phase is the final design of the base building (Saari 2001). A clear distinction between the fixed base building and the infill has to be agreed in the documentation before the procurement, infill design, and implementation activities begin. For managing efficiently the overlapping activities as e.g. in CM, the final conceptual documentation should focus on presenting only the base building for bidding. Especially the HVAC documents should become essentially lighter presenting in the conceptual phase only what is needed for the base building. Traditionally the client gives an exact and numerical program for sketching. Conversely, for the separate base building and infill, sketching defines the program through testing variations by e.g. the number of negotiation rooms, HVAC reservations etc. Because the amount of sketching work is not based on an exact program, the number of the variations has to be agreed on in the contract.

In the construction phase, designers provide approval, designing, and negotiation services for procuring and for the infill. Before the implementation, the designers and the contractor have to agree on the procurement strategy of each bidding package. The stages of completion of the design packages are determined according to their agreed aesthetical, functional, and utility values and according to their agreed level of planning participation by the tenderers. The model finds three levels of completion namely (1) the final drawings (2) the "directive design", and (3) the aesthetic, functional and technical requirements (Salmikivi 2005). The completion stages have been tested successfully in Finnish cases. Lighter completion levels may increase the architect's approval procedures and interaction with the tenderers, which has to be taken into account in the contract

This article evaluates the productivity of architectural design and the construction value chain especially from the viewpoint of CM. From the point of view of design management the architect's responsibilities have to be carefully defined in the design contract. In addition, one fee system or contract form, as a traditional fixed fee, may not perform optimally in all phases. It may be less fruitful for the stakeholders to develop totally new methods as opposed to simply improving one's understanding and carefully tuning the existing processes. A valid question concerns for whom is the value truly created; occasionally the designer may be creating additional (or negative) value for the contractor, but at the client's expense.

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IMPLEMENTING A VALUE BASED APPROACH TO CONSTRUCTION

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Abstract
Value is *the* end-goal of all construction projects and therefore the discussion and agreement of value parameters is fundamental to the achievement of improved productivity and client/user satisfaction. The word 'value' tends to be used rather loosely in daily practice. Similarly, terms and interpretations vary within construction management literature. The aim of this paper is to put forward a number of definitions that may be used in a common language for discussing and implementing value. Value creation and value delivery are clearly defined within a four-stage model that maps key process functions. Mapping the process provides a framework in which to highlight the differences between value-based management, value management and value engineering activities. The concept of external and internal values is also introduced. The model described is being implemented on pilot projects in Denmark, by consultants NIRAS and contractors MTHøjgaard. The model is grounded in extensive practical work and underpinned by theoretical constructs.

Keywords: Communication; Culture; Lean Construction; Value based management.

INTRODUCTION

Lean Construction has been a topical subject in Denmark since consulting engineers NIRAS and contractors MTHøjgaard introduced the methods in Denmark in 1998/99 in an urban renewal project in Copenhagen. Since then lean thinking has spread to a growing number of companies, universities, clients and unions forming the subject of academic debate and being implemented in a variety of ways. The growing interest of the conceptual thinking behind lean lead to the creation of Lean Construction Denmark, initiated and promoted by the Danish Technological Institute with assistance from the Lean Construction Institute. Lean Construction Denmark forms the basis for achieving a common understanding, a common language, and a forum for improvement and evolution of future application. Lean construction was originally interpreted very narrowly, represented by the Danish term *trimmet byggeri* (trimmed building), which relied almost entirely on the early 1990 experiences from the project Sophienhaven in Hillerød (Buildinglogistics #1 and #2, 1993 and 1994) using logistics, primarily in the flow of materials and activities, and the Last Planner System (Ballard, 2000) and the seven flows (Koskella, 2000). Over the last three to four years the thinking has evolved and moved further up stream to include the entire design and construction process in the lean approach. The realisation was that without being able to specify the best value for the client it is meaningless to define waste. Such developments should also be set against the Danish emphasis on (project) partnering as the 'solution' to the sector's problems. This has resulted in some confusion of terminology and mixing of terms and concepts, without a clear understanding of what partnering or lean really means. Similarly, the manner in which partnering concepts and lean ideals interact, if they do at all, needs further exploration. Our aim in writing this paper is not to argue for a theory for lean construction, nor is it to argue for a best practice model. Instead the paper aims to describe a value-based approach taken by a large consulting company and contractor working towards the realisation of a common goal to improve the building process. Critical evaluation of the methods described has not yet commenced.

THE VALUE UNIVERSE

To take a holistic and integrated approach to the design and construction of buildings within a lean framework means getting everything right at the start, or at least getting the costumer values as right as possible, thus helping to avoid unnecessary and costly changes/re-work loops later in the production process. This is the case in lean manufacturing, where considerable effort is put into the design and planning stages before production starts, and where considerable attention is given to customer values and the implementation of a zero defect production process. Early planning stages consume considerable amounts of resources, but when production starts there is complete certainty because everything has been meticulously planned, hence saving considerable resources downstream. We argue that this should be the case with construction. There are many differences between manufacturing and construction activities, but that does not mean that the same approach and philosophy cannot be applied to the process. This means giving more time to the early phases and subsequently shortening the construction phase.

In Denmark a value-based building process model has been developed through a series of trials, starting with the HABITAT consortium managed by NIRAS (Bertelsen, 2000) and further evolved in the publication *The Client as the Changing Agent* (Bertelsen et. al.2002), based on experiences from HABITAT and a pilot project William Demant Dormitory in Lyngby (Christoffersen et. al. 2003). The approach is that the lean philosophy (minimising waste, maximising value) should be applied as early as possible. It is here that decisions concerning value, design, procurement routes, timescale and budget conspire to set the scene for everything that follows (in line with the ideals promoted and popularised by Womack *et al*, 1991*;* Womack and Jones, 1996). Combined with a clear set of values the briefing exercise (also known as 'programming' in Denmark and 'architectural programming' in the US) and early design operations can be managed in such a way as to reduce downstream uncertainty and associated waste.

If value is as crucial to define as we think, we need to answer the questions: (1) Value to whom? And (2) what is value? Both questions are difficult to give a precise answer to. Is it the value to the owner, the user or the society we mean, or maybe even the value to the architect, engineer or contractor? And in what time perspective do we define value, when we construct, when we use or when we demolish and recycle? We could also ask if value is only connected to the building (product) or is it also connected to the processes that lead us to the product?

Value to whom?

This question becomes increasingly difficult to answer as we investigate the interests of the participants in a project. Going back to the definition of productivity, it must be the client/customer/society that defines the value. We tend to spend our money where payback is highest, and so usually it is the buyer who decides what is most valuable, not the participants of the delivery team (e.g. architect, engineer and contractor). Clearly the delivery team members have values as well, but they are (or should be) concerned with delivering the best value to their client, otherwise (in a perfect market) the client will look elsewhere. So we separate the value of the interests into:

- External value, which is the client/customer value, and the value that the project should end up with and the delivery team focusing on achieving.
- Internal value, by and between the participants of the delivery team.

This definition helps differentiate between values of the client and values of the delivery team, and these are not to be confused. It gets increasingly complicated when we investigate the external value because the definition of the client is not clear. The client often represents a lot of different stakeholders (the users, the investor, the owner etc.), and furthermore when we build we affect our neighbour and the surroundings (city/landscape etc.) and these stakeholders all have a different set of values and levels of interest in the project. When we know that the perception of value is subjective and individual, and that it changes over time, how do we map the values and satisfy all the stakeholders? The 'thinking' of values in the process method reflects the client complexity and provides the background for further investigation of the client complexity. When we go through our value-based method, we have in mind the value landscape represented by:

- Stakeholders (owner, user and society).
- Time perspective (when we design and construct, when we use and then recycle).

What is value?

The distinction between client values as the focus and end goal of our efforts and internal values of the delivery team is made as mentioned above. The external value is separated into (i) process value and (ii) product value. Process value is about giving customers the best experience during the design and construction of the project. It comprises:

- 'Soft values' such as work ethics, communication, conflict solving etc. between the client and the delivery team.
- 'Hard values' such as the delivery teams ability to keep agreed time limits, cost estimates, quality of the product and workers safety etc.
- Values that come from the actual design and construction process. As an example of this kind of value, renovation works in a kindergarten could be used to teach the children about safety, creativity etc and thus generates process value that might not have been evident when the project started out. Learning from participating in the process is another value in this category.

The soft and hard values are, when agreed between the client and the delivery team members, defined as the partnering values for the project. In this sense partnering has meaning and is an essential part of the value universe. It is all about how to work together, and how to keep agreements between the client and the delivery team. Internal values of the delivery team are of course present and influence the manner in which the actors work together. Product values are mainly derived from Vitruvian values (firmness, commodity and delight), combined with harmony with the surroundings, environmental issues and buildability. These can be broken further down in a value tree, not to loose the overview, but to make sure that the client is guided through the entire value spectrum. Thus the delivery team can map the client values in the best possible way. Product and process values can interact, and especially when the product becomes visible, it could mean changes in the values or rather the interpretation of the values.

An important factor in the approach described in this paper is the establishment of common values, or at least the discussion between the stakeholders of the 'value universe.' Getting to know each other and thus establishing common values and/or knowing why values differ between the stakeholders is crucial to the method. Often the result of the value work will be the best compromise between stakeholders. Establishment of common objectives and common values are important objectives in the drive for greater cooperation and reduced conflict in construction projects (e.g. Kelly & Male 1993). Value is *the* end-goal and therefore the establishment of value parameters at the outset of a project are key to the achievement of improved productivity and client/user satisfaction. The purpose of this paper is not to try and define value in an academic sense, nor to present a tight definition of the term. In practice the term value is used very loosely, and we will retain that approach in this paper. The word value has two characteristics (Christoffersen, 2003):

- The perception of value is individual and personal, and is therefore subjective. Indeed, agreement of an objective best value for a group will differ from the individuals' perception of value
- Values will change over time

We view value as: an output of the collective efforts of the parties contributing to the design and construction process; central to all productivity; and providing a comprehensive framework in which to work. Value must be established before doing anything else. Emphasis is on value creating activities as the initial framework for the entire building process and thus the reduction of waste in the later value delivery phases. We are concerned with value-based management and the control of values, primarily through value management in the early stages of the project and through value engineering to deliver value in production.

Value thinking throughout the entire building process

A new understanding of the building process based on value thinking has emerged from the work and projects performed in Denmark. The process model separates the value thinking into two mental phases: Value Design, where the client value landscape is found and reflected in the conceptual design alternatives before entering the 'production phase' of the process. Value Delivery, where the best design alternative that maximizes the client/customer value is transformed into a production design and constructed with the aim to deliver the specified product in the best way and with minimal waste. Transformation between value design and value delivery is through the formal contract phase. Throughout the process the opportunity to learn through feedback exercises (loops) is used.

Central to the value-based model are a series of creative workshops, which have their roots in value management (see Emmitt et al 2004). Figure 1 shows a simple line of workshops, starting with the agreement of common process values followed by client intentions and discussion of abstract ideals and working through to a complete set of information prior to commencement of production. Niras refer to this as the 'Walt Disney Model' in recognition of the filmmaker's approach to process management. The term 'workshop' is used, although in practice this will comprise a series of workshops that deal with a particular issue, or value stage, which continue until agreement has been reached. Flexibility in programming is required to accommodate uncertainty in knowing how many workshops will be required. When problems with understanding and attitudes exist, additional workshops are convened to help explore the underlying values and tease out creative input. Thus from the very start the whole process is consensus based. Bringing people together and facilitating workshops is time consuming and expensive, but proven to be cost effective over the life of the project. The workshops are an essential tool to maximise value and to reach agreement, which helps to reduce uncertainty in production and reduce waste. Different cultures will exist from concept through to production and the workshops provide a vehicle for the addressing potential difficulties. Workshops are also continued at the production phase to better involve the sub-contractors.

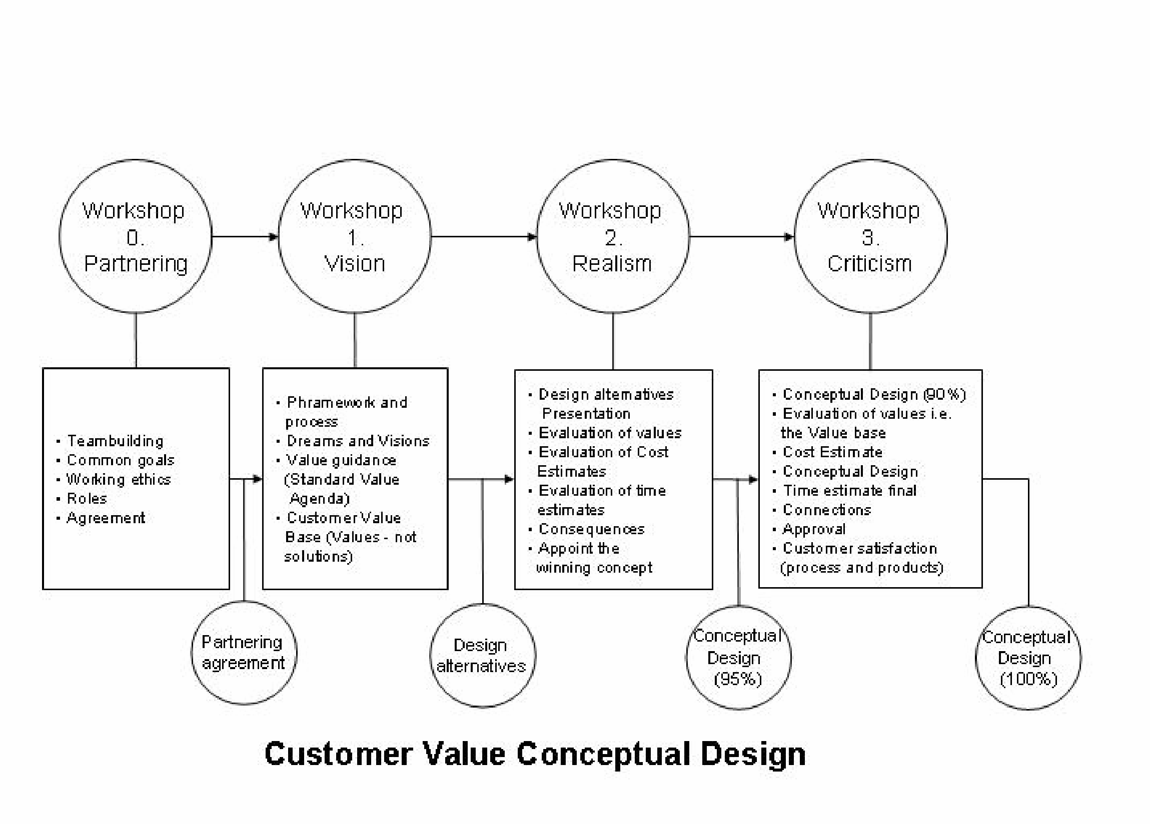

Figure 1. Creative workshop model (Value design phase)

Workshops are seen as 'value generators' (or value drivers) and are concerned with problem framing. Delivery of client value is achieved between the main workshops, where the problem solving takes place. Design alternatives are presented on the realism and criticism workshops reflects the client values. Project team meetings are used between the formal workshops to discuss and agree progress. The number of participants present in the meetings varies between projects and stages, however numbers typically range from between 15 and 30 people, although the organisational format can be changed to accommodate more people if necessary by dividing into sub-groups. It is a 'demand' of the project philosophy that the entire panel of participants is in place from the start to the finish. Using the journey metaphor the design and construction process is a change process (and a learning process as well), driven by the workshops. A standard value agenda is used as a framework for decision-making in the workshops. The 'basic value structure for buildings' is based on the six key areas of value; Beauty; Functionality; Durability; Suitability (for the site and the community); Sustainability (respect for the environment); and Buildability. This value hierarchy addresses the primary project objectives and breaks them down into further sub-objectives as part of an iterative process carried out within the workshops. Each area is explored until the value parameters have been mutually agreed through the use of the Value Tree. Tools like quality function deployment (QFD) can also be used to weight options (values) in a decision matrix to help find the solution that provides the best value. A process facilitator guides participants through the discussion of values in a systematic and objective way.

VALUE DESIGN

Customer Needs

In this phase the client is 'alone' in making their first thoughts of the project needs. Here it is important to address the client organisation and make a stakeholder analysis, in order to map the interests in the project. In this phase, the basic values of the client organisation can be mapped, together with the contractual framework represented as time and cost budgets. This mapping helps to form the basis of a value-based design brief.

Contact

Here the client takes contact to the delivery system in the way that reflects the preferred basic organisation of the project. From a value perspective it is preferable that all stakeholders (including representatives from the owner, the user, the operation and management organisation, the society – typically represented by the authorities) are present and that all competences in the delivery system (architects, engineers, contractors and suppliers) are also present – but of course seen in the context of the actual project.

Workshop 0: (Partnering) Building effective relationships
The function of the preliminary workshop is to bring various actors together to engage in socialising and teambuilding activities. The intention is to build the communication structures, the system architecture for the project, thus allowing actors to engage in open and effective communication during the life of the project, the architectural dialogue. In addition to setting the stage for the events that follow the 'outcome' of the first workshop is the signing of a partnering agreement between the participants. This confirms the process values for cooperation on the project.

Concept

Client need (represented with all chosen stakeholders) is specified and formulated into a basic value document. This document is a specification of client needs, not solutions. The conceptual design shall then seek to reflect these needs. All actors are influenced and equally interdependent on others for the realisation of tasks and projects within the temporary social arrangement of the project. Interconnectivity places additional pressures on the ability to communicate and share information and knowledge. Interpersonal communication, intra-organisational and inter-organisational communication is particularly pertinent to the establishment of an effective project communication network, and also for enabling learning to take place within the project, helping to improve the end value on this and subsequent projects.

Workshop 1: Vision

This workshop is concerned with discussion of basic product values and the establishment of product value parameters. It is not possible to know the values in depth at the start of a project, so workshops are primarily concerned with exploring values and establishing a common vision. Knowledge and experience from other projects is brought into the workshop, for example facilities management values to better inform the whole life approach to design and construction. The main focus of the effort is the establishment of client values (value-based parameters); on the basis that the better these are known the better the team can deliver. Collective dialogue helps to explore and develop relationships that can (or conversely cannot) develop into effective and efficient working alliances, essentially the preparation for the construction of efficient communication networks. Critical connections between decision-making are explored so that everyone is certain before going into production, thus reducing downstream uncertainty. The result of Workshop 1 is the establishment of basic values for the project; a very pragmatic document that does not contain any drawings. These values are prioritised.

Workshop 2: Realism

Workshop 2 aims to discuss how the basic project values may be fulfilled by presenting various design alternatives that reflect how they meet the basic value parameters, while at the same time addressing the contractual framework of the project – time and cost. Project economy is consequently introduced here along with restraints imposed by, for example, authorities and relevant codes. A number of alternative proposals are worked through and ranked according to value. Architects are encouraged to produce at least three schemes that can be presented and discussed at the workshop. During the realism phase normally at least two to three workshops are required, simply because there is a lot of material to work through. The basic project values and project economy are respected in this process and any changes justified within the value parameters. The outcome of the realism phase is the selection of the 'best suited' proposal.

Workshop 3: Criticism

This workshop(s) is designed to criticise the proposed design solution chosen in the previous workshop. The solution is criticised; is it really the 'best' solution? Could it be 'better'? Detailed discussion is centred on the chosen solution and its improvement within the value parameters. Uncertainty and urgency is high on the agenda prior to the scheme entering the production phases. Client (stakeholders) satisfaction with the process value and the product value is measured on the base of the partnering agreement and the basic product value parameters. Then the project is approved for production and the contractual delivery specifications fixed.

TRANSFORMATION FROM VALUE DESIGN TO VALUE DELIVERY

Contract

This transformation (signing of the contract) is executed when the Value Design work is complete, i.e. when the mental phase of the stakeholders and the delivery team participants has evolved to a stage where everybody agrees that no more/no better value can come out of the project, or alternatively when no more time is available. The focus changes from value design to value delivery where minimising waste in the delivery process is essential and value engineering activities are executed.

VALUE DELIVERY

Value Delivery comprises the final (detail) design and the construction of the project introducing ‘production thinking’ as well as the knowledge and experience from using (consuming) the building.

Construction

In this phase production of the agreed project is the focus, and the client plays a less active role. A lot of decision making still remains related to production activities, which are dealt with by the main contractor, working closely with the sub-contractors. The client role (supported by professional advisors) is to deliver detailed decisions as scheduled and to check that the specified value is delivered. Client and delivery team common process values (partnering values) are primarily concentrated on fulfilling contractual terms (time, cost, quality and accidents rates etc.) but of course still with respect to the ‘soft’ process values agreed earlier. Internal values of the organisations and persons working together in the delivery team are used to achieve a common focus when working on project delivery. In order to achieve an optimal communication between the participants in the delivery team, a series of production workshops is executed focusing on waste reduction in the process as well as in the product by value engineering activities and by introducing logistical tools, e.g. last planner. The production workshops are:

Workshop 4: Design planning
In this model it is here that there is a shift in thinking, as the more abstract work turns into production information. Values are concerned with delivery. The designers, contractor and sub-contractors interface most here as value management techniques turn more toward value engineering and a process management tool, Last Planner in a modified version, is introduced to help guide the planning of the process and results in a process layout of the design process similar to the process plan in construction. This approach was taken for the first time on the DELTA project and deemed a successful innovation it was used on NIRAS´ project for additional office space in their Allerød headquarters and in MTHøjgaard’s Gefion project in Frederikssund.

Workshop 5: Buildability
Here the focus is on improving the constructability of the project, while trying to reduce waste in the detailed design and construction phases by having the designers and the foremen/craftsmen meet with this specific value in mind giving their input to improving the design or focus it on the competences of the actual production capability and capacity.

Workshop 6: Planning for execution
These workshops involve interaction between the main contractor and the sub-contractors. A process plan is produced that helps to map the various production activities and help identify missing information. Information flow is an important consideration at this stage in the workshop model. On completion of the construction schedule, in an ideal world, the information should be complete and there should be ‘no scope’ for uncertainty of the delivered value at the production phases.

Control

The Control activity represents the finalisation of the project ready to be handed over to the building owner and the users going into the Consume phase of the project. The Control is executed with two goals in mind. First, to check that the product is perfect without any errors: second, to check that the product fulfil the client value specification agreed upon when writing the product delivery contract.

Consume

This phase is not discussed in this paper, other than to note its importance for feedback into future projects. It consists of facility management and operational & management activities, which help to give the knowledge and input to the experience loop. This forms part of the Value Design process on the next project and forms part of the experiential learning/knowledge transfer between projects.

CONCLUDING COMMENTS

Improvements brought about by the model have been confirmed in an independent study carried out by the Danish Building Research Institute, which found improved performance across a whole range of performance parameters (By og Byg, 2004; SBi, 2005). The model provides a simple design management tool that employs a value-based approach and incorporates the lean thinking philosophy. The creative workshops encourage open communication and knowledge sharing while trying to respect and manage the chaotic nature of the design process. Cooperation, communication, experience and learning as a group contributing to the clarification and confirmation of project values. Further work is required to investigate the effectiveness of, for example, the workshop method in terms of the realisation of group goals. In particular, the role of the workshop method in promoting and delivering creative solutions would be a logical extension of the research. So too would some reflection on lean production systems thinking in the detailed design phase. It is the intention of the authors that ongoing pilot schemes will be researched in an objective manner in an attempt to measure the success of the approach outlined here. A new project ('Telefonvej') using the process model by NIRAS and MTHøjgaard will be independently monitored and evaluated.

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STRATEGIES FOR VALUE IN THE PROCESS OF INDUSTRIALISED ARCHITECTURAL DESIGN

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Abstract
Increasing global complexity seems to create a growing need for simplicity, control and reliability. At the same time a new consumer culture calls for customized goods. Due to this development the traditional architectural design process is put under pressure leading to a demand of exact definitions of the values and qualities that can be used as governing tools in common building practice. Through detailed interviews with architects we examine how the architectural potentials are dealt with when dealing with modern industrial processes. The focus is architectural *quality* in design. How is this concept defined, how consciously is it being used among practitioners and finally which strategies are being used in order to reach specific goals in the production of architecture? A theoretical model consisting of four approaches for action is presented as a tool to structure the analysis and the approaches are then categorized along different dichotomies in order to point out different ways in which the offices can try to control the design process (strategies) and the end-result (goals). Two examples from the analysis are discussed according to the dichotomies and furthermore introduced into a general classification focusing on strategy. The project has several aims: a) To collect knowledge about actual design strategies used by the architects; b) To help offices identifying the characteristics and specific methods of working with architectural quality in an industrialised context; c) To provoke a general debate about quality in industrialised architecture.

Keywords: Architectural value, design strategy, industrialisation, professional culture, role of the architect.

INTRODUCTION

Contemporary design practice

Present challenges such as an increasing global complexity, the continuing acceleration of industrialization, as well as computer based communication and information technology, seem to create a growing need for simplicity, clarity, control and reliability at all levels of society and human life. At the same time we are facing a new consumer culture that calls for multiple and individual goods and which leads to specified quality demands. These tendencies also have an effect on contemporary architecture. They can be traced in the general aspiration for exact definitions of the values and qualities that can be used as governing tools in common building practice. Contemporary architecture then seems to be ruled by a mixture of quality standards and means that do not relate to the architectural project as a whole. It rather seems determined by a series of conditions (product demands, value-chain definitions, technologies and desires of the end-users) that are detached from the specific architectural context.

Due to this development of society the traditional architectural design process is put under pressure. In general the architectural design process concerns aspects such as intentions and meaning forming a process of translating visions into physical form, thus it may be considered as an essential activity in the creation of architectural quality. Various studies show that during the early stages of a project design (the concept and programming), 90 % of the final costs and qualities are defined (ATV, 1999). This way the architectural design processes deals with the inherent values that are possible to realize in a building project. Nevertheless the architectural design process is an ongoing movement of interpretation, mediation, and decision-making. Every step is difficult to fully plan and when it comes to the final output it is almost impossible to control.

Purpose
This project takes special interest in the architectural potential, which lies in the use of modern industrial manufacturing processes and the engaging opportunities when it comes to flexibility and customization. Due to modern computer technology and manufacturing building industry is no longer constrained to monotonous mass production as in the past. In this context the object (of the project) is to examine quality in design – meant as specific architectural quality. Questions that are studied are: How is architectural quality defined in specific architectural solutions, how intentionally is it being used among practitioners and finally which strategies and methodologies are being used in order to reach specific goals (architectural qualities) in the production of architecture today?

Defining Architectural Quality
Architecture quality holds a number various dimensions that are not identifiable within a traditional industrial context. The industrial concept of quality seems to have developed into a functional/technical matter whereas architecture and its qualities, as a cultural product, reach much further. Besides functional/technical issues architectural quality also embrace aesthetic and ethical aspects, - 'how shall one live to live in a right way' (Lundequist, 1992). As such the concept of architectural quality concern fundamental human existence (needs and aspirations) and its core values can be said to have existed unchanged as long as Mankind has existed. In order to summarise: The industrial concept of quality is quite contemporary and primarily a narrow rational concept, whereas the concept of architectural quality can be characterised as an overall human premise. Architectural quality is here defined as both objective and subjective matters such as; delicate materials, proper construction solutions, the ambiance of a room, the sense of balanced proportions of a facade system etc. It includes technical aspects, aesthetics, functional schemes, economy, ecology, time, place and other values. Architectural quality forms a synthesis of these elements and can be characterized as a holistic perception of our physical environment, where every constituent part seems significant and irreplaceable within a particular setting. This means that architectural quality cannot be expressed as a single formula and furthermore it is not possible directly to compare different levels of quality between different objects. The very nature of the architectural design process as well as the concept of architectural quality therefore seem to be challenged by the processes linked to industrialized manufacturing and computer technology which both require strict planning and a predictable output.

A THEORETICAL MODEL
Through detailed interviews with practicing architects the project examines how, and to which degree, design strategies are used in the attempt to attain a certain level of architectural quality. All the architectural offices that have been interviewed present interesting attitudes to industrialized architecture and the interviews and following analysis tries to decipher how they work in order to reach their final results. These results are not necessarily single building constructions. In our definition of industrialized architecture the works represent the overall

building concept, building systems as well as (industrial) design principles leading to particular results.

As part of the project we have developed a theoretical model consisting of four approaches for action, which helps to categorize and structure the different ways in which the offices try to control the design process and the end-results. The approaches are not meant as exact representations of any empirical reality, but are an attempt to collect a series of related motives for action, sorted out as clear-cut strategies. They are used as a tool in the analysis and in the discussion of the empirical results reflected in the interviews, but at the same time they are also an outcome of these interviews. In this way the model is meant more as a dynamic tool than as a rigid framework. Through the work with the analysis the model has constantly been corrected and refined. The intention is to make the model useful outside this specific research project and furthermore it is meant to create consciousness and discussion among practitioners and students about how they work.

The four approaches contained in the model are named the pragmatic approach, the academic approach, the management approach and the conceptual approach. Each of them represents different strategies along four sets of dichotomies. These are: architecture as an autonomous vs. conditional discipline, project vs. process orientation, innovative vs. evolutionary working method and intuitive vs. explicit accumulation of knowledge.

The pragmatic approach

This approach starts from the belief that 'good architecture' is ordinary buildings that work well and are made for ordinary people. The world sets up a basic framework from which you start. The role of the architect is not radically to change the world, but her mission is to present qualified proposals and increase the general standards. Knowledge is collected through a kind of apprenticeship based on routines and tradition and it is developed through working with specific projects. Knowledge is produced and held by the involved employees in each project. There is no systematic cross-project evaluation and transmission and you deal with what is possible within the given frames and conditions. Objectives concerning architectural quality are defined during the specific programming and the sketching process. A caricature could be the craftsman. Summing up the pragmatic approach would be that architecture is dependent/conditional. The approach is primarily project-oriented, based on tradition (evolution) with an intuitive non-explicit use of knowledge.

The academic approach

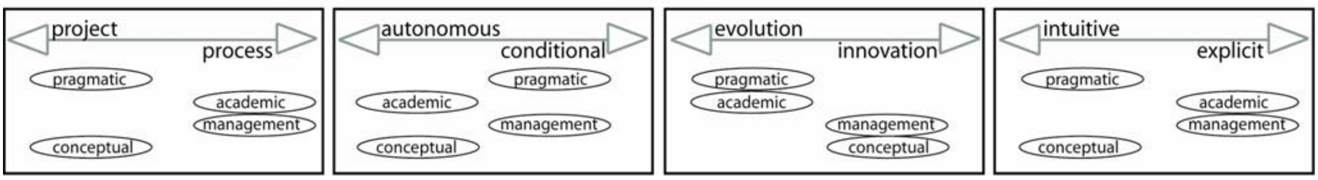
Behind this approach you will find an understanding of architecture stressing the holistic perspective. Only the architect can fully get a hold of this complexity, which nevertheless is created through interaction between various parties each one contributing with specialised knowledge. The role of the architect is to interpret and synthesise the many different inputs. Knowledge is systematically gained and critically held up against present knowledge. This means that knowledge is accumulated directly within the company. The working method is fixed and specific well-known solutions (typologies) are repeated while constantly adjusted and refined. The different tasks are specified so that responsibility easily can be distributed. Objectives concerning architectural quality transcend the project level as e.g. sustainability, lower costs or exploitation of the potentials of the daylight. Through a fixed method one try to reach some defined goals of quality. The caricature would be the scientist. Summing up the academic approach claims architecture's autonomy. It is primarily process oriented, based on tradition (evolution) and has a high level of explicit knowledge accumulation.

The management approach
This approach starts from the belief that architecture is created by the tension between different players both inside and outside the building industry. The architect has no special status in this context. Efficient coaching/management, rational thinking and good business are musts to attain good results. Knowledge is based on theoretical models and internally collected experience. The business administration controls the total amount of knowledge as a platform for decision-making. A keyword is business organisation and through specialisation of each employee controlling and directing each ones effort becomes easier. This assures an optimal use of all qualifications within the company held by its employees. By possessing sufficient economical resources in each project as well as in the company as a whole, room for innovation and new ideas to emerge is made. A caricature could be the manager. Summing up the management approach claims architecture's conditionality. It is primarily process oriented, innovative and has a high degree of explicit knowledge accumulation

The conceptual approach
Architecture is conceived as an art in this approach. Every building must – regardless of technological limitations and restrictions – be a unique statement, which claims more than just to be the physical framework for human activity. To work as an architect is a vocation. Every work (of art) has its own special premises, which means that you cannot transfer knowledge from one project to another. This can even restrain the work. Every project must start as *tabula rasa* where a particular concept sets up the framework for possible action. This concept might originate or be inspired by part of reality but generates its own logic. The quality is embedded in the value of the concept, the degree of innovation or the special characteristics as well as in the clarity of the final result, which should also be able to solve technical and functional requirements. The approach can be caricatured with the artist. Summing up the conceptual approach claims architecture's autonomy. It is primarily project oriented and innovative and has an intuitive non-explicit use of knowledge

The four approaches are to be understood as neutral in the way that we do not try to favour one approach from another. On the contrary the assumption is that *all* approaches can result in a high level of architectural quality. The approaches are an expression of a cultivation and collection of a group of related characteristics. In reality the actual practice will always be more ambivalent and thus often point towards different approaches simultaneously. Practice can be a complex combination of different strategies.

figure a - the different approaches placed within the four dichotomies



CONCEPT AXES

To further illustrate the model Figure A sets up the four different concept axes or dichotomies used in the summing up of each approach. The figure and dichotomies should help to hold them out from each other and facilitate the comparison of the different approaches.

Process/project

The first axis or dichotomy is a process/project axis, which describes where the focus is when the architects are at work in the studio. A process focus starts from the assumption, that controlling the process is the best way to control the result. The way you do things has great influence on the final outcome. This means that the specific working methods often have a general character directed towards *how* you do, which is not necessarily linked to any special characteristics in the actual project. The project focus starts the other way around with the aim – the project. This makes the process more arbitrary or improvised in the way that 'anything goes' as to reach the goals set up *a priori* in a specific project. A specific end result can be an outcome of many different processes. The working method is thus postponed in relation to the product/project.

Explicit knowledge accumulation/intuitive non-explicit use of knowledge

The second dichotomy deals with the nature of the knowledge used or could also be illustrated as the *media and code* used for information storage and exchange. Explicit knowledge accumulation mainly uses external media and universal codes[1] e.g. paper/pen (media) and letters/English (code). This type of knowledge accumulation facilitates communication and exchange by making it more independent of the actors involved in this communication. Intuitive non-explicit use of knowledge is stored in the actors themselves and codes are personal or at least limited by personal access[2]. This knowledge can be conscious but are more likely to be part of the subconscious. The actual knowledge accumulation will always be a combination of the two extremes. This has to do with the interpretative act, which will always be involved in the translation of any form of information independent of media and code into useable real time knowledge. It is not without importance *who* is reading a text or looking at a drawing.

Innovation/evolution

The third dichotomy spanning from innovation to evolution is related to the *use* of knowledge in the generation of new ideas. Innovation has to do with the ability or the intention to throw away what you already know and take in completely new information without prejudice. This knowledge can be both consistent knowledge generated in external environments[3] and more *ad-hoc* based knowledge generated by a specific combination of conditions in the specific case and situation. Evolution means that the main part of the knowledge, or information, employed in a project is already possessed by the actor (the architect) before the beginning of the project. Compared to nature itself evolution is based on *mutation* where minor corrections and refinements make an

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[1] Universal codes do not exist. In this context universal should be understood as 'shared by a large number of individuals'. Even shares codes will contain an interpretative element.

[2] An extreme way of attempting to surpass this personal access could be the use of torture.

[3] Knowledge collected from other related or non-related fields

organism (or object or process) more apt in a certain environment, context or situation. Again reality will always be somewhere in between. You cannot start completely from scratch even if you wanted to. There will always be reuse of some basic knowledge e.g. how to use a pen or the dimensions of the human body (in architecture). On the opposite total reuse will not generate new ideas (and will not even be evolution).

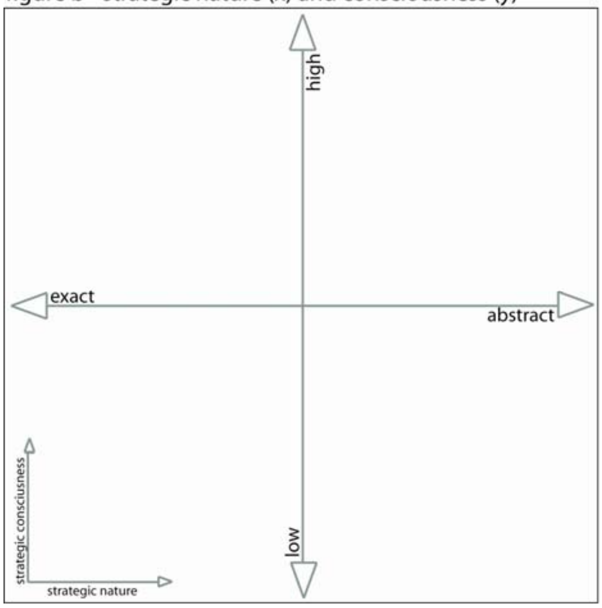
Autonomous/conditional
The last dichotomy runs from architecture's autonomy to ditto dependency. An autonomous architecture is an architecture which is exclusively defined within it self and the architect possesses monopoly when it comes to decide what is relevant to include in this definition. This has to do with a conception of architecture as a true profession rather than an occupation (demarcation/action). Architecture's dependency on the opposite places the architect as one actor among many others in the production of architecture. This is not necessarily constraining for the development of architecture; the blurred borders can be seen as possibilities and inspiration rather than limitations.

The axes represent a simplified way to classify the different theoretical approaches. This should help to make the model as a whole a useful tool for analysis and discussion of specific empirical reality in this research project represented by a collection of interviews with different Danish and foreign studios of architecture. The interesting part of an analysis would not make an exact match between reality and theory, but rather to discuss the clashes between the rigid classifications and the ever-complex reality.

EXAMPLES FROM THE ANALYSIS

The analysis of the empirical results is structured around the theoretical model. Each of the interviews has been scrutinised looking for characteristics relative to the different approaches. The overall scope of the analysis and the research project as a whole is to locate different strategies and specific goals (in the process of architectural design). Design strategies seem to work on several levels and some of them are only indirectly related to the actual design process. A strategy can be directed strictly towards the formal design – the process of giving physical shape to a project. It can also have broader technical scope introducing special (industrial) building techniques or deal with more legislative themes like building regulations. The strategy can even focus on entirely external factors as power relations or politics, which are considered to have decisive impact on the actual design. As a general guideline one could look at the *level* and the *nature* of the strategy employed (see Figure B): *Level* refers to the level of consciousness: high or low strategic consciousness and *nature* point to a distinction between concrete (exact) and abstract nature of the specific goals implied in the strategy. In the present paper we will shortly present two examples from the analysis which both present high strategic consciousness but of very different nature spanning from the concrete (exact) to the abstract.

figure b - strategic nature (x) and consciousness (y)



Exact (concrete) Strategy
One of the cases we have studied is the architectural office Lundgaard & Tranberg (LTA), a middle size Danish company with 35 employees founded in 1974. In the mid-nineties the office developed a building concept or system called 'Comfort House', which is based on a business consortium that joins NCC as contractor, Carl Bro as engineers and LTA as the architects. The concept or system is partly an organisational framework partly a constructive system for housing complexes of varying size. We interviewed the actual owner Mrs. Lene Tranberg.

The statements found in the interview places LTA closest to the pragmatic approach. However many features are also related to the conceptual approach while the management and the academic approach share no significant resemblances with the way LTA seems to work. En very general terms the approach can be characterised as clearly project oriented mainly using intuitive non-explicit knowledge. Furthermore LTA does not state architecture's autonomy while both innovative and evolutionary features can be found. In Spite of *Comfort House* being a system the starting point in LTA is the actual project more than a general strategy. There is no fixed procedure and neither a complete *tabula rasa*. The constructive framework gives some common directions for the different actors involved in the process but leaves a great deal of openness for the architect in some specific parts e.g. designing the façade and organising the plan. The common set of rules make it possible for the involved actors to work more simultaneously as e.g. the engineer not having to wait for the final solution from the architect to calculate the structure. LTA's design strategies run in two directions; on the one hand they accept the framework and focus on the possibilities within it and on the other hand they always try to challenge the repetition, which also characterises the system.

The project oriented focus, characterised by the pragmatic approach which is also prevalent in the LTA-interview, results in very specific strategic statements[4] e.g. improvement of building components and detailing or how these are related to the whole. Examples could be LTA's work with a greater deal of flexibility where the foundation meets the ground, various placements of the plane of the façade or the use of alternative materials. The analysis points to a moderate to high level of strategic consciousness directed towards exact (concrete) goals. (Figure B).

Abstract Strategy

A second example we would like to present is an interview with Per Feldthaus from Arkitema (AT). AT is the biggest architectural office in Denmark and was founded in 1970. The firm shows an explicit interest in industrialised processes and was among other reasons selected because of its size and because of their biannually published knowledge balance (Videnregnskab) – a written and illustrated summary of what they know and where they want to focus in the future. PF is one of 11 owners and the managing director of AT. The interview places AT close to the management approach. AT's approach can – in general terms – be characterised as mainly process oriented. Explicit knowledge accumulation is the aim and to some degree a fact. AT does not state architecture's autonomy but claims extreme dependency on related fields while many innovative features are present with the aim to empower the architect.

The process orientation is found in the focus on organisation within the company and the organisation of the building process as a whole. However it must be stated that PF works at the organisational level which is not necessarily representative for all employed in the organisation. One of the initiatives is a pronounced specialisation of the staff which is placed in specialised departments with different profiles. A particular task force is specialised in research and accumulation of knowledge. This part of the company does not have any external costumers, but generate value and surplus more indirectly by supporting and inspiring the other departments. The role of the architect is not to decide what is wrong and right concerning architecture, but instead to enable the involved actors to make the needed decisions. The architect thus becomes a process manager more than a decision maker. By opening up and giving other actors influence on traditional working fields of the architect the possibility of gaining access to other decisive areas seem to be maximised. This turn the way the architect works upside down and points to pronounced innovative features.

Most of the strategic dispositions presented in the interview points towards a more general level (non project specific) with focus on the process instead of on the final product. Strategies are less directed against internal factors e.g. specific formal design and more against external factors e.g. the coordination with other parties involved and questions about the organisational setup of the construction process. One of the major problems in the building industry, according to PF, is precisely the improvised character of this organisational setup. The analysis points to a high level of strategic consciousness directed towards abstract goals. (Figure b.)

[4] Important is to underline, that it is not possible to compare the interviews directly with each other. The conversations do not necessarily treat the same topics and do not take place on the same level. This can in itself result in strategies on different levels.

No strategy
Both examples that have been analysed present a high degree of strategic consciousness, but of different nature. To complete the schema other offices that have been interviewed present considerably lower strategic consciousness mainly of an exact (concrete) nature which in many ways corresponds to the pragmatic approach. A low strategic consciousness of more abstract nature would correspond to an extreme version of the *conceptual* approach although figure 2/3 cannot just be understood by locating each of the four approaches in a quadrant. All cases that have been selected present interesting attitudes towards industrialised architecture and are consequently located in the 'conscious (upper) end'. An allegation could be that many traditional offices would be located in the lower conscious end thus presenting low or no strategic consciousness at all. The aim of this project is not to confirm this, but instead to contribute to make these companies more conscious about the way they work.

IMPLEMENTATION AND FURTHER PROJECTS

The model of action has been presented in various contexts thus trying to agitate for a more conscious strategic approach among architects. There is a difference between not being conscious and *choosing* not to be and our argument is that given the new and industrialised context as described above there is definitely a need for this conscious choice. This not only seen as a means to empower the architect as a professional person and the profession but rather to emphasize what is more important: the *architectural quality*. As presented in the introduction the traditional design process is under pressure and in this context it is our opinion that new measures must be taken to insure that design is not reduced to cost control, industrial just-in-time production or building code. These might be important issues but should be submitted and measured against a more general approach including all the other important aspects of a *holistic* architectural design process. Through publication in architectural magazines (Arkitekten 06/05, Nordic Journal of Architectural Research etc.) by means of workshops and future courses arranged on the School of Architecture in Copenhagen and through presentations at relevant design conferences (CIB W096, Joining Forces etc.) we try to make the project more than a final report to be placed in the bookshelves of other researchers. It is our hope that the model can and will be used by the offices in discussions about strategy and that it can contribute to make more conscious the ways we – as architects – define and try to reach goals concerning architectural quality.

Two parallel projects have been formulated as a follow up on this project. One project dives further into the action-perspective. Through observation studies carried out in studios selected among the present cases we intend to study the actual *processes* taking place when architects work on a specific project. One thing is how people *talk* about what they do and another is what they actually *do* when they work. The thesis is that the correspondence between these two levels can vary considerably and it thus becomes interesting to analyse both sides – especially with a focus on the strategic consciousness described in the previous section.

A second project focuses on the *product* that comes out of the building process. Dealing with design it is a fact that you can never claim that a specific process will lead to a specific previously defined outcome. It is therefore equally relevant to analyse the actual *works* or results. The aim is to develop the terminology and concept formation on architectural quality in an industrialised context claiming that this will to some extend differ from its more traditional equivalent. We need new or supplementary concepts to be able to talk about and furthermore to better understand the (industrialised) architecture we find today. When executed the two parallel projects will be used to describe characteristics of the relation between process and product. The division in two main concepts is thus meant as purely analytical; it helps to clarify certain aspects about a reality that will always be a complex web of 'interaction' between the two.

One could ask if industrialisation really needs a special terminology. Is industrialised architecture really something new or different? We no not think so, but the circumstances under which it is produced – and especially the number of actors involved in the process – have changed considerably making building a complicated activity. The world develops and the architects and the building sector must develop as well to be able to deliver modern buildings to modern people. The aim of this research is not to reject the traditional role of the architect, but to challenge it making the architect more conscious of her own choices and architectural values.

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THE VALUATION OF INTANGIBLES: EXPLORED THROUGH PRIMARY SCHOOL DESIGN

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Abstract
It has become commonplace to refer to the potential for good design to lead to schools that raise educational attainment, as well as offices which promote teamwork and productivity, and hospitals where patients recover more quickly. These claims correspond with a considerable re-awakening of interest in the impact of the built environment on outcomes and a growing evidence base. Some private sector organisations have deliberately invested in architectural design to achieve specific, if intangible, outcomes, but recent public sector audits of schools reveal designs where best practice has not been achieved and where the rhetoric about design and educational attainment is unlikely to be matched in reality. There is a need both for better evidence about the impact of design on outcomes, and for ways to quantify the benefits of good design so as to take them into account in affordability calculations. The pilot study reported here investigates the impact of good design on 'improved pupil supervision', 'increased attendance', 'better well-being', 'enhanced educational attainment', 'flexibility of teaching spaces', and other intangible benefits. The paper concludes by suggesting that improved understanding of the impact of design on outcomes, combined with new valuation methods for capturing intangibles, should raise awareness of appropriate levels of investment needed to achieve design quality and deliver particular outcomes.

Keywords: Architectural value, design quality, intangibles, outcomes.

INTRODUCTION

The last five years or so has seen a remarkable revival of interest in the impact of good design on outcomes, and educational is one of the sectors where this revival is particularly pronounced. Other sectors include healthcare and offices. There is a long history of interest of this kind. In the nineteenth century for example, E. R. Robson, architect to the London School Board, stressed the therapeutic value of sunlight when he wrote:

'It is well known that the rays of the sun have a beneficial influence on the air of a room, tending to promote ventilation, and that they are to a young child very much what they are to a flower.' (Robson, 1874)

Accordingly, schools of the period used tall windows to admit light, and high- and low-level opening lights for controlling ventilation. Between the first and second world wars, there was a revival of these concerns and a renewed interest in the physiological benefits of sunlight which influenced the design not only of schools but also health centres and sanatoria. Large windows, often in horizontal bands, were an architectural expression of the desire to admit light.

In the second half of the twentieth century a more 'scientific' approach was taken towards the study of buildings and their impact on people under the heading of 'architectural psychology' (Canter & Lee, 1974). However, a subsequent reaction against the notion of 'architectural determinism' – the proposition that there is a direct causal and mechanistic link between the built environment and human behaviour – resulted in many of the lines of enquiry effectively ceasing[5].

The revival of interest in the UK on the impact of buildings on outcomes follows a decade when built environment research was strongly focused on business process improvements in construction aimed at making the industry more efficient by: cutting waste; reducing costs; encouraging collaborative working arrangements; improving health and safety, and exploiting information and communication technologies.

Gradually the design community responded through initiatives about the quality of the product. The RIBA Futures Group commissioned two essays on *the value of architecture* (Worpole, 1999, Loe, 1999). The RIBA Practice Committee formed a Constructive Change group and organised a conference in 2000 called *Design Quality – the evidence*. The Construction Research and Innovation Strategy Panel (CRISP) convened a Design Task Group. The Construction Industry Council commissioned the Science Policy Research Unit to develop Design Quality Indicators as a means to assess the product – in response to the Movement for Industry's Key Performance Indicators with their emphasis on benchmarking the construction process. Housing Quality Indicators were devised. The Royal Academy of Engineering published a paper on *The long term costs of owning and using buildings* which promoted whole life costing and introduced the *1:5:200* ratio between *initial capital cost*, *lifetime facilities costs* and *lifetime business operating costs* as a reminder to clients that it was important to look at the possible improvements to staff productivity and business outputs of a well-designed building rather than just the initial capital cost.

Most significantly of all a new body CABE, the Commission for Architecture and the Built Environment, now funded jointly by the Department for Culture, Media and Sport (DCMS) and the Office of the Deputy Prime Minister (ODPM) was brought into being. One of CABE's early successes was to influence government to launch the *Better Public Buildings* campaign intended to bring about a step change in the quality of our public buildings. The introduction to the campaign said:

'…we know that good design provides a host of benefits. The best designed schools encourage children to learn. The best designed hospitals help patients to recover their spirits and their health. Well-designed parks and town centres help to bring communities together.' (DCMS, 2000)

CABE also took on the major task of collating the evidence about good design and its impact on social and economic outcomes. Its first cross sectoral report *The value of good design* stated:

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[5] Although the Environmental Design Research Association has successfully continued to run conferences every year since 1969.

‘Good design is not just about the aesthetic improvement of our environment, it is as much about improved quality of life, equality of opportunity and economic growth. … Good design does not cost more when measured across the lifetime of the building or place …’ (CABE, 2002)

CABE went on to commission literature reviews in several key sectors –schools, healthcare, housing and urban design, and in some cases turned the understanding into design guidance (CABE, no date).

OUTCOMES IN THE SCHOOLS SECTOR

Schools figure prominently as a sector where there is widespread interest in good design. Feilden (2004) championed the need for evidence to demonstrate that ‘well designed’ new buildings provide better academic results than ‘poorly designed’ ones so as to help ensure that new schools offer genuine value for money through improved functionality, performance of pupils, and recruitment and retention of staff.

Two major investigations have been carried out by PricewaterhouseCoopers for the Department for Education and Skills (PricewaterhouseCoopers, 2001 and 2003) the first of which found that capital investment in school buildings had a positive influence on staff morale, pupil motivation, and effective learning time, while the second reported that capital investment in premises (and IT) had a measurable impact on learning outcomes.

More recently a group from the University of Newcastle’s Centre for Learning and Teaching has undertaken a review (Higgins, Hall, Wall, Woolner, & McCaughey, 2005) examining the literature on:

- What makes a good school (physical) learning environment;
- What impact do (physical) school learning environments have on student behaviour, motivation, learning and achievement;
- Which components/elements of school learning environments make the most difference to pupil behaviour, motivation, learning and achievement, and why;
- What evidence exists to indicate the relative balance between the physical environment and the emotional and cognitive environments on pupil behaviour, motivation, learning and achievement?

The introduction to the paper notes three striking features of the literature:

- ‘the relative paucity of research on effective learning environments’ and that completed research ‘seems to be largely predicated on a traditional view of ‘chalk and talk’ learning in standardised ‘one size fits all’ institutions’.
- that ‘it is the extent to which, and the ways in which, school users are engaged in the school design process that determines the success or failure of the resulting design. The message is clear. School designs cannot be imposed nor bought off–the-shelf.’
- that ‘in a changing world no design solution will last forever, so the process of user involvement must be continually refreshed and iterated to support ongoing change.’

The review’s conclusions about the school built environment are that:

- There is strong, consistent evidence for the effect of basic physical variables (air quality, temperature, noise) on learning, but that once minimal standards are attained, evidence of the effect of changing basic physical variables is less significant.
- There are forceful opinions on the effects of lighting and colour, but the evidence is conflicting.
- Other physical characteristics affect student perceptions and behaviour, but it is difficult to draw definite, general conclusions.
- The interactions of different elements are as important as the consideration of single elements.

PUTTING A VALUE ON INTANGIBLE BENEFITS

A widely acknowledged difficulty with many of the benefits associated with good design is that they are difficult to measure, or intangible, and this makes it difficult for those who procure buildings to assess how much it is worth investing in design and in construction. This is a topic first investigated by Rouse (2004) who describes how a number of corporate clients tried to measure architectural value to justify their investment in it. All the case study organisations recognised the corporate benefits from architectural investment, representing both tangible benefits of the sort that can be counted by traditional cost/benefit but also intangible benefits that are more difficult to measure. Employee satisfaction was the most highly rated motivation; human capital is the major resource of the organisations and they seek to enhance the ability of their employees to contribute to turnover and profitability. Corporate policy in architectural investment was also very important; design champions at senior levels within the organisation and corporate precedents for high quality architecture were both found to be important. For seven of the ten organisations, procuring a building was part of a much wider corporate development process – with the goals typically of transforming how the company does business; encouraging creativity, enhancing communication, promoting team work, operating less formally, encouraging flexible working and reducing hierarchy. Rouse argues that if the benefits of architectural quality and value can be demonstrated and quantified then additional investment into the built environment can be released.

In the private sector, some well-informed clients such as those studied by Rouse, are - to a greater or lesser extent - aware of the potential of good design to add value, are prepared to invest to ensure that value is delivered; and have explored cost/benefit type methods for assessing value. Elsewhere however, and particular in the public sector where concerns about accountability can discourage the exercise of judgement and discretion, there is a greater need for evidence about the delivery of value from good design and new methods for valuing intangible benefits. In the absence of quantification of delivered value, there is a perennial risk of building down to a cost rather than up to a value. Documented examples can be found in the schools sector where an assessment by the Audit Commission (2003) found that architectural quality was below best practice for both traditionally funded and early PFI schools, while a similar assessment of early PFI schools in Northern Ireland reported that: ‘Poor internal environments were widespread and likely to lead to impact on educational achievement’ (NIAO, 2004). For all the rhetoric about good design, it is not always delivered in practice.

In a direct follow on from Rouse's work, a study was undertaken on *improving the valuation of intangibles* which resulted in a classification of stakeholders and the outcomes they value, and a model which identified six different types of tangible and intangible value delivered by buildings – use value, exchange value, image value, social value, cultural value and environmental value – and suggested benchmarks that could be used to measure them (Macmillan, 2005; 2006). A key suggestion from the study was the need to move away from a single point value towards a probability curve for quantifying value – future valuation methods may offer ranges of values or a value profile, rather a single number. A matrix approach was also identified as a way of illustrating connections and dependencies between different sorts of value. Mulgan's (2005) identification of the potential of 'value maps', visual diagrams that set out in graphic form the relationships between different types of value and the flows of value they achieve, has a resonance with that work.

THE PILOT STUDY

In May 2004, a pilot study was conducted on a new build primary school to investigate perceived intangible benefits – which values may be raised by its design quality – and to obtain initial feedback on valuation of intangibles.

The pilot case school was opened on 15 June 1926. It has been located on a split site for 18 years and neither of their buildings was adequately fit for purpose. A new school has been designed using the best of modern construction techniques to meet the demands of modern teaching and the community facilities and leisure opportunities that the school also provides. The new school building, whose construction works started on 15 October 2001, was opened in September 2002. The inquiring process involved interviewing the headteacher, an education officer and the architect of the school.

The interviewees were asked to rate on a scale of 1 to 10 (with 1 being the least important and 10 being extremely important), nineteen possible purposes of school design. The results are presented in Table 1. Out of nineteen purposes of the school, 'enhanced educational attainment' was rated the most important element. Other purposes that were considered as highly important include 'calm environment', 'flexibility of teaching spaces', 'users satisfaction', 'adaptability of school building', 'better well-being', 'safe routes to school' and 'improved pupil supervision'. Clearly many of these are intangible and difficult to measure and quantify with any degree of certainty.

The three interviewees were aware of the underlying value in the school delivering these intangible benefits. However, no attempts had been made to measure the benefits nor to place a value on them. Nor did they have ideas for how to measure the value of these intangible benefits. When asked, all three said they would be keen to use new valuation methods if they were available. An argument similarly put forward by the three interviewees was that better recognition and proper valuation method for intangibles may enhance design standards of the built environment. The main concern of the interviewees was the difficulty of devising such methods. These illustrate the existence of a need to explore alternative method for valuing intangible benefits in the built environment.

Purposes of school design	Rating			Total Score
	Head teacher	Architect	Education Officer	
Enhanced educational attainment	10	10	9	29
Calm environment	10	9	8	27
Flexibility of teaching spaces	10	8	8	26
Users satisfaction	9	10	7	26
Adaptability of school building	10	7	8	25
Better well-being for occupants	9	8	8	25
Safe routes to school	9	8	8	25
Improved pupil supervision	10	8	7	25
Provides community use	9	8	7	24
Meets educational guidelines	6	9	9	24
Healthy internal environment	9	7	7	23
School's profile in the community	8	9	6	23
Security and safety	10	7	6	23
Cost efficiency	8	8	6	22
Functional quality	8	10	4	22
Reduced Vandalism	8	7	7	22
Increased attendance	6	7	8	21
Parents and visitors	8	7	6	21
Local Education Authority satisfaction	6	8	4	18

Table 1: Rating of purposes of pilot case school design

The study reported here is a pilot for a more in-depth set of case studies currently being undertaken. It is not possible to report meaningfully upon the outcome until full-scale fieldwork comes to an end. However, the pilot results show encouraging signs that key stakeholders of a newly built primary school can identify the intangible benefits that have been provided by the design quality of their new school buildings, and that there is a recognised need for valuation methods that allow these benefits to be defined in some measurable way.

DISCUSSION

The inevitable reality in real estate and construction investments is that clients always expect better value for money. Given today's emerging trend towards the concept of whole-life value, intangible benefits in buildings – such as corporate identity, staff productivity, or customer experience – are becoming increasingly acknowledged and, in property valuation methodologies, important in determining real estate value. Although traditional valuation methods, based on market value principles, typically lack the capacity to capture these tacit values, in the private sector the mechanisms of the market are able to some extent to credit intangibles. For example, the corporate image created by an architecturally prestigious office is likely to be reflected in its rental or yield. There is evidence of organisations commissioning bespoke buildings where purely commercial considerations are overridden in order to obtain intangible benefits, and methods have been devised to credit intangibles as reported by Rouse (2004). In the public sector, however, the market mechanisms are absent, and the requirements of accountability and auditing reduce the opportunities to exercise judgment unless it is supported by facts and figures. In the absence of suitable valuation methods, the opportunities to invest in design quality so as to deliver intangible benefits are held back. This is in spite of a widespread recognition that buildings offer a wide variety of benefits to clients, users and other stakeholders (Cooper, 1982) and are rich in the range of underlying values they hold for different people at different times (Groak, 1992).

The development of alternative methods for valuing intangibles has the potential to drive a whole-life perspective and lead to long-term improvements in the built environment. Capturing and expressing underlying values will help surveying and valuation practices to mature, and assist surveyors in making more explicit and credible ‘value judgements’ (Lamont, 1955). In combination with improved understanding of the impact of building design on stakeholder outcomes, new valuation methods have the potential to lead to more informed debates about affordability of initial capital costs of construction, and also about the benefits of evidence-based design and its affordability. At best, new methods will enable wiser investments to be made, leading to greater value-for-money for both clients and society. Knowledge of intangibles should provide worthwhile value drivers for improving quality and value in the built environment.

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EXPLORING THE POSSIBILITIES OF CORRELATING MANAGEMENT WITH VALUE IN ARCHITECTURAL DESIGN

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Abstract
In the past decade the management of complex architectural design processes has challenged several researchers to develop theories, methods and techniques on how to handle these management processes most effectively in order to reach the maximum value. Now the time has come to draw a plan for the future and bring these models into action. Empirical data appear to be hard to find in this field of research because of the complicated mixture of belief and science but the number of models on this topic is increased. Based on a literature review some evidence on the efforts of design management has been found in industrial product design management. In project management, architectural practice and construction management some studies successfully tried to capture parts of it. This paper explores the possibilities of starting a research project to develop a scientific measurement method that connects input factors with outputs in terms of value in the field of Design Management. Which similarities can be found in practice concerning steering elements that correlate with creating architectural value? How can we design a measurement technique for architectural value and how can we capture steering techniques? Because of the ambiguous and complex nature of these questions, this future research project will probably exist of experimental research methods, based on qualitative and quantitative evidence as well as belief.

Keywords: Design, Management, Measurement, Quality, Value.

INTRODUCTION
The activity of architectural design is a complex phenomenon. Many aspects can be distinguished (Achten, 1997): the process of designing is a cognitive process in the sense that the architect is problem-solving, creating, learning, exploring, etc.; architectural design is a social process in the sense that the architect has contact with many design participants in a variety of relationships; it is a cultural and technical phenomenon situated in a specific cultural context; and it is a process of dealing with uncertainty and establishing useful artefacts. It is the designer's task to integrate and co-ordinate design constraints and to find a way to convert constraints into positive elements (Suckle, 1980 in Bártolo, 2001), as designers need to balance qualitative and quantitative criteria in their decision-making processes. From the other, more engineering, perspective, design is a process that transforms client requirements (input) into design objects (output). It is a process where values for the customers are created through the fulfilment of their requirements. It is also a flow of information, which has to be controlled and distributed effectively in time and space in order to eliminate waste or inefficiencies (Ballard & Koskela, 1998; Sebastian, 2004). All these processes have to be managed. Design is always a blend of different views. Designers and managers use different kinds of knowledge and experiences and managers perform different roles. It is the intersection of different 'worlds' and speaks different 'languages' (Bucciarelli, 1994 in Sebastian, 2004).

On top of this, there is the problem that the language of management is almost as much based on belief as it is on facts.

Building design, process design and organization design are three core elements of the design environment. In design, object and process often overlap and it is difficult to draw a sharp line demarcating where the 'hard' object ends and the 'soft' social process begins. Traditional management could be counterproductive, particularly in contemporary large, complex and fast projects; it creates self-created problems that seriously undermine productivity. But making design subject to management is still assumed, at least by the designers involved, to result in the death of creativity. And professional managers tend to shy away from architectural design, which is seen as a black box not to be opened (Prins, 2004). Cornick (1991) tries to open parts of the black box in his book on quality management in building design. He states that he is not affecting the creativity by implementing management techniques because his solutions focus on the input and output and not on the synthesis part, which he claims to be the part where creativity occurs. His view is one of many.

Buildings are built as projects: a temporary endeavour undertaken to create a unique product or service (PMI). Koskela & Howell (2002) mention three kinds of goals for project management: getting intended products produced in general; internal goals such as cost minimization and level of utilization; and external goals related to the needs of the customer, such as quality, dependability and flexibility. In building projects this is no different. The intended product, the internal goals and the external goals from the definition of a project can all be seen as values created by a building project. The parties involved want to finish a building of the highest quality that meets their requirements at minimum cost in the shortest possible time. A design environment is necessary to accomplish these goals. From the literature a distinction can be made between project performance (meeting requirements on time within budget), process performance (fluently facilitated process), and product performance (building perception, quality and financial value). This paper focuses on the relation between process performance and product performance within the field of architectural design.

PROJECT PERFORMANCE: METHODS AND SUCCESS FACTORS

Project management methods all express the need for more or less hard factors such as a feasibility study, an analysis of needs, clear briefing, an evaluation of requirements, software tools to support the load of information, planning and control of time, cost and money, a consistent project team, and a return on investment. More innovative methods focus on more soft and intangible 'higher' factors such as shared understanding of stakeholders' values, integrated design, collaboration contracts between parties, overall understanding of requirements, dynamic briefing systems, creative learning environments, a well thought out communication and information strategy, user involvement, life-cycle cost analysis and innovative fee structures. Chan (2004) describes a framework of critical success factors in construction management found in a literature review in seven major management journals. The study of project success and the critical success factors (CSF's) is considered to be a means to improve the effectiveness of a project. Five main categories are found: human related factors (e.g. experience, client characteristics, project team), project factors (type, complexity, size), project procedures (procurement, tendering), project management actions (e.g. communication system, planning, control mechanism) and external environment (social, economical, political etc.). It is hypothesized that the project will be executed more successfully if the project complexity is low; if the project is of shorter duration; if the overall managerial actions are effective; if the project is funded by a private and experienced client; if the client is competent on preparing project brief and making decisions; if the project team leaders are competent and experienced; and if the project is executed in a stable environment with developed technology together with an appropriate organization structure. These categories and hypothesizes create a frame when explicating the relationship between performance and project characteristics.

PROCESS PERFORMANCE: MODELS AND FRAMEWORKS

As mentioned earlier, the architectural design process consists of social, cognitive, cultural and technical aspects that have to be dealt with in great uncertainty at individual, organizational or practical and team or project level. Design Management therefore covers a wide range of functions, starting with the self-management of individual designers and ending as part of the management of the total project through integrated building project management. Problems occur while trying to capture these steering techniques because of the interactive character of these activities. Models are available on how the influence of steering theoretically should work. The different steering levels of personal, organizational and project interests stress the field of tension between professional ideals and company interests in architectural practice (Doorn, 2004). To link the business processes to the design processes, strategic, tactical and operational design management can be applied. According to Sebastian (2004) all current design and project management methods have failed to penetrate the creative and subjective nature of architectural designing, especially during the conceptual design phase. He therefore developed a framework based on a social psychological approach that should promote human creativity to reach the ultimate goal: the realization of the design whereby both the object and the collaborative process are able to meet the classical management parameters (e.g. time, cost, quality) as well as the contemporary management parameters (e.g. value, performance, satisfaction).

The mission and strategy of the design firm will play a part in finding a suitable management technique. Allinson (1997) recognizes that the strategy of an architectural practice can create added value and distinguish the firm from others. He tries to encourage architects to focus on planning, monitoring, analysis and control as well as on team management and human resource management. Combining design and management will lead to better service delivery, both in design and in organizational culture. From a management perspective this might sounds logically but from a designer’s perspective this view is often seen as the death of creativity. According to Gray et al. (1994), an essential condition for effective design management is knowledge and understanding with regard to architectural value and the essentials of design processes, designers and design organizations. They identify two levels of responsibility for the design and its production in design management: the associated authority for decision-making, and responsibility for the interface with other organizations. The task of the design manager is to ensure that the organization of the design process is structured appropriately and that there are sufficient integrative and coordinating mechanisms for the work to progress meaningfully. A framework therefore has to be established to keep the focus on the tasks and objectives so as to achieve the value criteria laid down in the initial stages. Although these guides and frameworks stay relatively close to traditional project management, they certainly help focussing on design quality.

Kestle & London (2002) state that design management is such a complex process because it is concerned with value generation, the integration of specialist knowledge, a shared understanding of the objects and the critical timing of key decisions. This shared understanding towards identifying what is valued in the project affects how critical decisions are made in respect of design issues. The authors tested a design management model for the development of performance-based briefing and analyzed group interaction among stakeholders. The premise was that there was no need for an external chief decision-maker, but there sure was a need for a design manager to integrate and manage knowledge held by the stakeholder groups. According to Prins et al. (Prins et al., 2001), design management focuses especially on facilitating the creation of architectural value in the broadest sense by the coordination and facilitation of (design) processes in the framework of the integrated management of time, money and quality. This extends from a thorough understanding of clients' and occupants' needs to a sense of social and cultural responsibility. Domain knowledge about architecture, technique, design and management is essential. The creation of value can be facilitated through the strategic management, process design and control of collaborative multidisciplinary design of buildings so as to fulfil the expectations of all the parties concerned, either directly or indirectly (Prins et al., 2001).

Because of the social and complex technical design environment of building projects, teamwork, decision-making and knowledge management play an important role. Design decision-making is often negotiated amongst groups and teams – it is an iterative process so that the design management should work in a cyclical form, alternating between setting-up the strategy, formulating the process layout and directing the process (Kestle & London, 2002; Prins et al., 2001; Doorn, 2004; Kruijne, 2003). The nature of complex group dynamics affects design and building performance criteria. In assembling a team, careful consideration should be given to the level of professional experience, the design experience and the personalities of the team members, and to whether the team is sufficiently multi-disciplined (Shen & Liu, 2003). Having a clear objective that is understood is crucial for directing the process and concentrating participants' efforts.

FACTORS THAT INFLUENCE PERFORMANCE

Research studies that focus on performance and input factors provide us with ideas on how to study the relationship between management and design. Oydele (2005) performed a research study to examine and compare the performance of Nigerian architects in public and private sectors. A framework of criteria was therefore set up consisting of criteria for client focus, quality of work, buildability of design and the use of management systems. Through a survey consisting of statements on a Likert scale among 135 experienced clients of Nigerian architectural firms Oydele discovered that private sector clients are likely to be more concerned with cost, while public sector clients are more concerned with buildability of design. Pre-design meetings, identifying and prioritizing objectives, knowledge of materials are very important and co-ordination between design phases, identifying and prioritizing objectives, quality management strategy, pre-design project meeting and project review meetings were best-performing criteria.

In new product development projects a few studies have been done before that both designed and tested a model in order to link management to performance. In product design quantitative data such as scrap and rework rates, defect rates and reliability are used to define internal quality, while market share, customer complaints, warranty and litigation are used to measure external quality (Ahire & Dreyfus, 2000). Ahire & Dreyfus (2000) distributed 418 surveys to find out if Design Management and Process management affect the external and internal quality of products. The use of the management methods is measured by statements on the involvement of users and use of management tools on a Likert scale. They found that both design and process management have an equal impact on internal and external product quality. There are many synergistic effects of DM, training and TQM. It shows that design efforts - such as concurrent engineering, cross-functional product development organization - have a significant direct impact on internal product design performance (defined as speed and product components). The same applies to the involvement of suppliers and customers in product and process design for the long-term success of quality programs and process quality management efforts - such as monitoring of scrap rates, rework rates, defect rates, and corrective actions. Quality training and the use of quality tools are also useful in attaining high levels of product design performances and process quality management efforts. The results of a survey study of 131 completed NPD projects by Swink (2003) suggest that project acceleration interacts with project content, leadership and integration variables to affect on-time performance differently across NPD projects. These effects can be explained by the fact that due to the acceleration, the difficulty of the project also increases the value of leadership, integration techniques and careful decision-making increases.

STEERING TECHNIQUES

A few empirical studies in the Netherlands have tried to capture steering and management techniques on a scientific basis using observational and experimental methods. Oranje (2004) looked at the design process by specifying the relationship between Zeisel's design process (image – present – test) and the cognitive steering activities of recording, interpretation and intervention. Oranje used protocol analysis for several meetings in two case studies. Image and Testing activities by the designer were mainly followed by result-oriented interventions by the project manager and employer instead of activity-oriented interventions. In the case of activity-oriented interventions, pro-active and indirect interventions were mostly used instead of reactive interventions. Presenting is steered pro-actively as well as reactively. The results of this study can be used in order to describe the interventions that can be used by project managers and employers to steer the architect and his/her design process. Another study looked at organizational steering techniques within architectural practices. It shows that steering takes place at different levels in the (project) organization. Fraats (2003) focused in her study on the use of the means of budget, planning, information, communication, IT and employees and found three, mostly corresponding, levels of steering within the firm: steering by the management, internal project management and steering by the controller and quality administrator. She used document analysis, observations and interviews in a Dutch architectural practice known for the good management structure. Results suggest that apart from steering based on processes and results, steering from within the organization as well as the project organization in respect of both soft and hard components are necessary. Processes have to be facilitated while results have to be controlled for soft and hard factors. But in this Dutch practice, steering is mainly performed in respect of hard factors or means and in terms of results. The tuning of information and communication between these processes is essential. Fraats (2003) clearly found Architectural Design Management as the link from policy to practice, while the link from practice to policy was found to be weak. Because of the fragmented character of Design Management she was unable to identify any special position whatever with responsibility for design management in its totality.

Kruijne (2003) initiated research into the relationship between process design, process steering and the level of integration that is being reached between the building design and the design of the climate installation. His view is holistic but appears effective. The process was mapped by document analysis and interviews. The results of the process were measured at three levels of integration, with synthesis as the final goal, based on 12 criteria rated by the architects and project managers involved in a total of 55 projects. Remarkably almost all the experts agreed on the level of integration. The research study could not find a significant relationship between early or late involvement of the climate consultant and the intensity of consultation of the design team, but a relationship between the existence of an information plan and a higher level of integration was established. The results suggest that not the amount but the effectiveness and efficiency of the consultations are related to the final level of integration and that a project manager can steer more effectively as regards integration than can the architect.

PRODUCT PERFORMANCE: DESIGN VALUE

The term ‘value’ in an architectural context is also known as build quality. Most of the latest literature on build quality originates from the UK, partly related to the discussion about the DQI. Quality in building design embraces all the aspects by which a building is judged such as uniqueness, functionality or durability. It always involves a relative and balanced consideration of tangible and intangible costs and benefits and a willingness to give up in order to gain (Best & Valence, 1999). In product design the terms internal and external quality are used. Internal quality is defined as the quality of the components and the manufacturing process of the product. External quality is the effect of the product on the market (Ahire & Dreyfus, 2000). From the background of Value Management, value depends on balancing the three factors of time, cost and quality against the client’s requirements, while retaining the basic ideal, i.e. to complete the project at minimum cost, in the shortest possible time and to the highest possible standard. At the same time, there will also be a willingness to satisfy the client’s needs, including those related to function, aesthetics, business goals and image (Best & Valence, 1999).

Although theoretically tangible and intangible costs and benefits have equal weight in decision-making, in practice tangible factors are seen more often as a valid basis for decision making than intangibles. Macmillan (2005) describes the results of a strategic study on intangibles. The participants in the study underline the fact that is a common experience in architecture that the desire to deliver value for money is often interpreted as cutting costs rather than raising values. The idea put forward by the working group is not to replace the existing methods but to extend the range of factors taken into account beyond the economic in order to enhance social and cultural values as well. The group developed a matrix with type of value created, bundle of valued outcomes and examples of indicators or metrics. Defining the relative importance or weighting the values and capturing the relationships between the values in graphic form would also be beneficial in considered decision making. To open up the world of anecdotal, academic and unsorted information more data need to be collected and published. Designers need to be more engaged in the delivery of outcome and the willingness to increase short-term cost for long-term gain has to grow. The 'black box' of valuation needs to open up (Macmillan, 2005).

PERCEPTIONS OF ARCHITECTURE AND DESIGN QUALITY

In line with Einstein one could say that 'facts are just facts, it's the perception that really matters'. According to the Dutch architect Carel Weeber, a building's architectural quality is determined not by the professionalism with which it was built, but by the part it plays in architectural debate. A building only becomes architecture when it is discussed; the fact that a building is well thought out professionally is not enough to make it a piece of architecture (Voordt & Wegen, 2005). Architectural professionals would say that quality of design may only be determined by peer experts. Rossum (1996 in Voordt & Wegen, 2005) studied architectural quality as perceived by a number of architecture critics. Building, function & context, internal consistency and form, function & meaning were defined as components of quality. Environmental psychologists like Kaplan & Kaplan, Berlyne and Prak found that mystery, complexity, coherence and legibility are important issues in the preferences of the environment. To understand and to explore are basic needs of people in environments. Usmani & Winch (1993) define aesthetic quality under the headings of unity, expressiveness, magnitude, function and stability, as a means of providing a structured approach to assessment. According to the architects' answers in Bártolo's research (Bártolo, 2001), quality design involves characteristics such as 'creativity, good form, composition and proportion', attention to detail, simple and elegant use of space, integration of services and fulfilment of users' requirements within a stimulation environment'.

The introduction of the Design Quality Indicator brought about a discussion among researchers in the journal Building Research and Information about the term and measurement of design quality. Prasad (in Macmillan, 2004) describes quality as the achievement of a totality that is more than the sum of the parts. She argues that design quality can only be achieved when the three quality fields of functionality (use, access and space), built quality (performance, engineering systems and construction) and impact (form and materials, internal environment, urban & social integration and character & innovation) all work together as circles. Non-overlapping areas of the circles represent very basic things to get right, regions with some but not total overlap represent the added value, while in the middle all three quality fields overlap and one obtains true excellence. The basic things are just as important as the excellent - without the basics there can be no true excellence. Classifications like these - based on Vitruvius - still appear to be widely distributed because other organizations use similar distinctions, e.g. the sub-qualities of Voordt & Wegen (2005): functional, aesthetic, technical and economic quality, the variables of the Tavistock Institute (in Macmillan, 2004) - architectural merit, internal quality, accessibility, cost in use, environmental friendliness and energy efficiency, viability of the proposed procurement route, overall value for money, cost provision and risk assessment and involvement of artists and tradesmen - and the principles of good design by CABE - functionality in use, built quality, efficiency & sustainability, designing in context and aesthetic quality. In spatial planning, values are divided into experience, future and user value, added to narrative (storytelling or inspiration) and assumption (private or public perception) value (Lengkeek, 2000). Narrative and experience value correspond with architectural value while user, future and assumption value appear to correspond with functional, technical and economic quality.

MULTI-USER QUALITY PERSPECTIVES

Poor integration of specialist user and producer stakeholder knowledge can have far-reaching consequences, such as inappropriate synthesis of the needs analysis, resulting in low value generation for the client and users. In many cases identifying value is a socially constructed process among the stakeholders, who incidentally are not just design and construction teams but are those actors who can contribute to improved design and construction building performance (Kestle & London, 2002). According to Best & De Valence (1999), the success or otherwise of a building will be decided according to a complex mix of judgements offered by a range of interested parties. Prins (2004) developed a framework of architectural value in which he supports Pirsig's view that value can be considered as the 'metaphysics of dynamic quality'. This value concept addresses the goals, needs, ambitions, wishes, dreams and beliefs of all the participants in the entire life-cycle of a building from initiation to demolition, so architectural value is not confined to users and clients but extends to society as a whole and the other stakeholders involved in a project. It is based on the triangle of spiritualism, planet and profit and includes the multi-user perspective.

Nowadays the awareness that all participants have to be involved in the design process is high. But putting ideas into practice requires a lot of perseverance and strength. The stakeholders can change through the various stages of the design, construction and occupancy stages and each group of actors may have a different perspective depending upon their worldview. The power to negotiate and guide design decisions and assist with establishing building performance criteria changes at different times of the process – in many cases their voice is not heard at critical times (Kestle & London, 2002). Users can be seen as important stakeholders in the product, but there is debate as to whether they are also important stakeholders in the process. User participation does not automatically ensure satisfaction, but it is argued that user exclusion invariably results in dissatisfaction. Becker's research (1991 in Brown, 2001) concluded that appropriate user involvement was beneficial in the briefing process, but that the involvement of certain user groups at certain stages could actually be counter-productive. Another critical noise is the fact that by reaching a consensus between parties, the possibility of a high ambition for one facet of the project is very low. And practice teaches that shared ambition is one of the main keys to success.

DESIGN QUALITY INSTRUMENTS

The field of environmental psychology has focused on people's expectations and needs in the built environment for years now. By using quantitative research methods such as experiments, observations and questionnaires, data are collected, e.g. on aesthetic preferences and ways to improve the feeling of safety. Post Occupancy Evaluation collects experiences concerning the use of the building and would seem to be key to how to design, because it looks at how things are and not how they might be (Macmillan, 2004). But evaluation research cannot make precise predictions for future users because priorities can change over time and according to circumstances. Evaluation studies could theoretically be used as input for new projects to improve the value of the building. In practice this is hardly the case. The psychological research often failed to provide the conclusive or applicable results that practitioners desired. Apart from the fact that POE's are performed far too late, results are handled as company secrets and results are not well translated into useful design languages. For example the pattern language of Christopher Alexander - the most famous design language - is hardly founded on scientific data but shows the experience and tacit knowledge he built up as a practitioner. On the other side there continues to be a lack of interest and willingness among designers to invest in this area of research (Dewulf & Meel, 2004).

It needs to be borne in mind that, in decision-making, not all stakeholders are willing or able to define their interests and goals at an early phase in the design process. Evaluation tools used in the 'old' situation often give the stakeholders the ability to think and discuss design quality instead of costs in the 'new' situation and to provide support for the continuous process of helping clients and users find an optimal spatial solution (Dewulf & Meel, 2004). The Maslov pyramid of needs can be used to explain that values are constant, but interpretation may be variable and dependent upon one's situation at any point in time. It is natural that priorities will vary for different interest groups, sectors and time-scales.

An evaluation tool cannot only focus on the product because process and product are intertwined. In the Work Environment Diagnosis Instrument - developed by Volker & Voordt (Volker & Voordt, 2005) at the Center for People and Buildings – an evaluation of the implementation process was included in this POE tool because the entanglement of product and process was recognized in prior research on work environments on (new) offices. In developing the tool the researchers found that results of the evaluation often not only led to short-term interventions but also triggered the rethinking the real estate policy. The Design Quality Indicator has been developed by the UK Construction Industry Council (CIC) to measure design quality in the brief phase as well as in use. The critiques of this method cover the full range of difficulties of measuring the quality of design. The existing quantitative and 'positivistic' studies have great value for science and practice but fail to address the more 'soft' and intangible aspects of quality, which only together define the excellence and 'delight' of design. The divergence in quality perception between different stakeholders is well-established. The DQI accepts that quality is subjective and uses only subjective measurements. It is, however, open to question whether the full range of quality issues can be scientifically measured in subjective terms instead of by the collection of facts and figures (Dewulf & Meel, 2004). We have to realize that we might not be able to construct a tool that both provide us with valid scientific data to use as input in new processes and at the same time starts up a discussion in which we ask ourselves what we actually want in design quality.

MEASURING PERFORMANCE

In relation to quality two distinct aspects may be considered: a quantifiable quality and a subjective quality (Bártolo, 2001). Quantifiable quality refers to ‘conformance to requirements’, a rigorous means of controlling the conformance of the product against predetermined goals. Quality Management methods are based on this principle. Subjective quality concerns a personal response to built form, people’s perception of space, scale, texture, colour and light, the meanings and associations attached by people to places and the way in which people assign aesthetic qualities to their surroundings. The subjective quality is very difficult to quantify; it is essentially a question of perception and consequently a question of characteristics. Boon (2001) also states that utility can only be measured in an ordinal (not cardinal) sense, which is that consumers can only rank market baskets in order of preference but that the degree of utility or preference cannot be measured.

Gann & White (2003) identify three approaches for looking at value and design quality. The judgement-based approach is adaptive, focusing on the experts’ abilities to evaluate the design product. The ‘manage and measure’ approach is based on a belief that designers can make rational responses to social, economic and environmental needs, and research has been focused on achieving better design by measuring, management and integration of the process. In the middle lies the rational-adaptive approach, which accepts that quality is a difficult and uncertain aspect to measure but that the development of tools to think about the impact of the design could be beneficial. The authors endorse the multi-actor approach of design processes in stating that design quality reflects multiple viewpoints of communities of design professionals, and of user groups, including lay people. Because of the recognition that tacit knowledge plays an important role in good design, that there are routine and innovative non-routine design activities and that it is often beneficial to try and accommodate similarity and difference at the same time, Gann & Whyte (2003) remark that we have in large part moved away from efforts to measure, analyze and control every facet of the design process. As a consequence some practitioners only rely on their own expertise while shutting other stakeholders out, while others try to develop new methods to assess risks, options and choices in multi-criteria environments.

In order to explore the correlation between design management and architectural value variables need to be defined. The idea of measurement is often regarded as a threat to those things that are held as most precious in architecture – the surprising, simultaneous, civilizing and place-making aspects of the built environment. However, to reject measurement is to ignore its value of communication and transparency and as a means of rendering explicit the relationships between subjective and objective criteria (Prasad in Macmillan, 2004). Some of the features that one might wish to measure and eliminate in order to improve construction processes might relate closely to those that provide additional value during design (Gann & Whyte, 2003). The problem is that most of these aspects are complicated and highly obscure. Views on how to manage design vary greatly but nobody seems able to capture the whole. Therefore people try to control parts of the process, hoping that their particular part will cover the critical majority - all falling back on the iterative character of designing and the impossible combination of creativity and management. As noted by Oliver (in Macmillan, 2004), the problem with measuring is that 'as soon as we leave the measurable sphere of the project, with its cost targets, agreed product form, and time-frame, the map of design leads into a territory that is both hard to measure and filled with competing voices claiming to be our guides'. However, if all experts from the same stakeholders' perspective agree on the misfit between the delivered value and the value that has been desired, we might have a grip. We might not have to open up the black box of design and process value, but instead content with similarities or patterns that represent their value. These patterns can be matched within certain limits to correlate the design value with the (perception of) used steering techniques. In future research we will have to define the existing patterns and explore the limits in which they are valid.

CONCLUSION

Designing is a complex phenomenon which consists of cognitive, social and cultural elements on which decisions have to be made. Although some theories have been developed on how the design process takes place cognitively, the design process is still seen as a black box. The solution of the design problem withholds its value. There is probably no best way to manage design, no best way to design and no one universal value. The experience of quality originates in the confrontation between the individual and the object, building or place and this concerns the characteristics of the individual, the object and the situation. Processes consist of interactions between stakeholders. A high quality process does not necessarily result in a high quality product and vice versa. Based on the literature the results of a building project can be divided into product, project, and process performance. Not all of these variables can be expressed in objective numbers and clear data. The intangibles are therefore nearly seen as a black box too. Empirical data that combine steering activities with perception of product performance are hard to find. The solution of measuring these intangibles would be not to open the black box but to describe its perception, try to capture and characterize the (lack of) input factors and correlate these with the perception of the output.

Design management is not new; it has been included in existing activities. An important function of design management is to bridge the gap between user and initiator and act as an interface between a number of participants in the design process. The models that have been developed over the years for the management of projects, designs and constructions show similarities in the factors that are taken into account. We found some success and fail factors from project management perspective and dynamic software systems can support these management techniques to collect the right information needed in the process, accompanied by a well-thought-out communication strategy. In industrial new product development we found a few correlations between management and design quality. The research by Kruijne (2003) and several other architectural and psychological researchers proves the existence of similarities between groups of people in perceiving the built environment.

Within the future research we will have to experiment on measurement methods. We might vary expert panels to see when and if the quality level is judged the same. To detect steering methods used in project and architectural organizations we might use protocol analysis, other observation techniques and surveys. We might also experiment with different reflection-in-action techniques to stimulate creativity, inspiration and interaction. It's time to change our way of thinking about the measurement of management in design and try to capture the intangible and tangible qualities as a whole of patterns instead of fragmented pieces.

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GETTING TO GRIPS WITH CLIENT COMPLEXITY

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Abstract
Construction is a process of delivering value to the client through a temporary production system, which consists of elements that are shared with other projects. The completed works is a one-of-a-kind product that has been assembled at a temporary production facility, the site. This process is in itself a very complex system and one that has been studied to a great extent over a number of years. The production system is, however, only part of the process. The other part, and one worthy of more extensive investigation, is the client. The term 'client' tends to imply a person or a well-defined body of persons that act as a single entity, but in the majority of projects this is not the case. The 'client' is a representative for a number of, often conflicting, values, interests and time perspectives. When we take a closer look we find that the client is just as complex as the production system. More work into better understanding the client system may be a fundamental requirement for improving process and product quality. The paper investigates the characteristics of the client and the customer-supplier relationship in the built environment. Based on recent experiments in the Danish construction sector the paper seeks to identify some approaches to the management of client values; from which better value may be delivered to a wider range of stakeholders.

Keywords: Client, complexity, interests, stakeholders, value

INTRODUCTION

Construction is a process of delivering value to the client through a temporary production system, which consists of elements that are shared with other projects. The completed works is a one-of-a-kind product that has been assembled at a temporary production facility, the site: the amount of site assembly varying with the degree of pre-fabrication employed. The production process is a very complex system and one that has been studied to a great extent over a number of years (e.g. Bertelsen 2003). The production system is, however, only part of the process. The other part, and one worthy of more extensive investigation, is the interaction with the client. The term 'client' tends to imply a person or a well-defined body of persons that act as a single entity, but in the majority of projects this is not the case. The 'client' is a representative for a number of, often conflicting, values, interests and time perspectives.

In the 'lean' literature Womack and Jones (1996) popularised the objectives of lean production as maximizing value for the customer and minimizing waste (activities that do not generate value). This has proven an effective principle in practice, and has been used to develop the field of lean construction. Trying to apply the lean philosophy earlier in the design and phase, in accordance with the philosophy of lean, two fundamental questions arise. Who is the customer? What is value? Without understanding the customer, the concept of value is undefined, and without a tangible concept of value, waste is difficult to define in a meaningful sense. This is an important point to make in the context of design management, since it is the customer values that are being managed. The route to a leaner design and construction process should thus begin with a deeper understanding of the nature of the customer, or more precisely the client. So the questions can be rewritten as: Who is the client? How may client values be understood? The paper begins with a brief discussion of the nature of the client. It then reviews the nature of complex systems and their behavioural characteristics and along the way comments on client behaviour from these perspectives.

THE NATURE OF THE CLIENT AND CLIENT VALUE

Most construction organisations tend to take it as a given that the client is a well defined entity and that this entity has some very clear and well defined value parameters, which can be expressed in clear terms. Although the term 'client' appears to indicate a single person or a well-defined group of persons, each client entity is a complex system[6]. The client's representative may be one or more people, but they are no more than representatives charged with doing a job, rarely are they themselves the investors, owners and users of the building. This makes the capture and communication of 'client values' particularly difficult to achieve in practice. A small number of textbooks have addressed the client briefing stage, but they too tend to rely on relatively simple definitions of the client and/or holistic terminology and descriptions. For example, clients are commonly defined as being repeat clients, new clients, experienced (in building), inexperienced. Clients may also be defined as having short-term (developer) or long-term (owner) interests in the building. Some of the better books on client briefing have started to get into the issue of cultural values of the organisation and the transformation of those cultural values into the briefing process. There is little attempt to discuss the value system of the client (or client body) and how this impacts on design process. Looking closer at the nature of the client, one may identify behind the façade an organisation, which during the project execution should represent the interests of three distinct client groups — the building owners, the users and society. These three groups of interest each value different things at different times in the life of the building. The predominant focus is on when the building is completed and taken into use, where the classic Vitruvian perspectives: *Firmitas* (durability), *Utilitas* (usefulness) and *Venustas* (beauty) may be used as expression of the primary view of each of the three groups. But there also exists the perspective of the value of the building in the future or for future users, and the value while the building is being designed and erected – the often overlooked value associated with the construction process: some examples are represented in Table 1. To add to this complexity, value is a matter of personal opinion, which can and does change over time. Value cannot be measured or expressed and communicated explicitly, but must be learned and understood through a process, which can best be understood through a learning metaphor (e.g. Green, 1995). This gives rise to numerous wicked problems[7] during the construction process, not least during the initial design stages, which can be seen a symptom of complexity.

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[6] This is true even when the client is a single family — the client is not just the family; there are local zoning/planning laws that bring in the local community at the very least and building codes that are part of the client too. Now scale that up to a factory, office, school, ….

[7] *Wicked problems* are problems without an objectively 'best' solution. A wicked problem can therefore be worked with infinitely but in most cases the work stops when time or money runs out – or when the participants loose their interest in the problem. (Simon, 1969)

	Owner	User	Society
Primary Vitruvian Perspective	*Firmitas* (durability)	*Utilitas* (usefulness)	*Venustas* (beauty)
During Construction	Respect for cost and time Errors and accidents	User involvement Schedule	Noise Dust Traffic hindrance
When completed	Capital value Cost of operation and maintenance Durability	Flexibility for initial use Indoor climate, lighting Looks, landscaping Safety	Architecture Compliance with surroundings Environmental aspects
In the Future	Long time investment	Flexibility for future use	Landmark Aging in beauty

Table 1: Examples of Value Perspective in Construction

The prevailing understanding of construction as an *ordered* process (or a process that can be ordered through management of the project) may be incorrect. This misinterpretation may be the root-cause of the problems construction management meets again and again in practice. Using the term ‘emergent’ often seen in complex systems literature one may argue that the construction process is an emergent phenomenon used by an emergent system in an emergent setting. We argue that it is a process for an emergent customer as well. In other words the construction process is the interplay between two very complex, emergent and highly dynamic systems: the client and the production system.

COMPLEX SYSTEMS

Even though the world has always been rich in complex systems, at least since the Renaissance, Western engineering and management has adopted a rational perspective. Newton’s mechanics was the basis for this understanding and reductionism showed its usefulness; understanding the parts in detail gives a firm understanding of the whole. It was not until the first half of the 20th century, when quantum mechanics developed and called for a statistical approach to some parts of physics, that anyone challenged this approach in earnest and showed that there are systems that cannot be understood by looking at their details only. Around the same time it became clear that treating the world as a collection of linear systems, the approach in most sciences, might be a mistake. However, only a few had any concerns about this until the end of the century when the propagation of personal computers from the mid 1980s onwards started a revolution in thinking in a number of disciplines. Nonlinearity was no longer an issue for mathematicians but an easy matter of a few lines of code, and a new world opened up. Chaos (Lorentz, 1972, 1993), fractals (Peigten, 1986), strange attractors, self-organization and emergence became household terms. Gleick’s book *Chaos* (1987) opened the eyes of many, and the complexity approach spread into a large number of scientific fields.[8] Even with the growing popularity of complexity as evidenced in papers, reports and dissertations, there was no generally accepted textbook on the nature of complex systems. Waldrop’s *Complexity* (1992) is the most common reference, but we have taken the more systematic explanations found on the web pages of Lucas (2005) as our starting point in understanding complexity.

[8] Indeed, the complexity digest reports more than fifty papers and articles *every week*

Characteristics of Complex systems
According to Lucas, complex systems are generally characterized by:

- Autonomous agents – that is elements that may act on their own
- Nonlinear relations – that is relations between the agents, which are not simple and linear but characterized by feed back loops
- Non-uniform parts (agents and relations) – that is that the agents as well as their relations are not the same all over the system

Do these characteristics apply to clients? Clients have many interests that they are trying to satisfy, and in construction it is easy to recognize the autonomous agents in the many kinds of interest taken care of by the client. The concept of non-linearity may be new to many but in any practical setting this is the expression of feedback loops, which are fundamental parts of our daily life. The parts in the construction process in general (and the client in particular) are non-uniform. Thus we do have a complex system.

Lucas (2005) further lists 18 axioms about complex systems, including the three above. The other fifteen are concerned with complex systems' behaviour and can be divided into three groups:

- **General behaviour of complex systems**: looking at the system's organisation
- **Evolutionary behaviour of complex systems**: looking at the system's learning and development
- **Connective behaviour of complex systems**: looking at the *relations* between the parts instead of the parts themselves – i.e. reductionism

Lucas' *Quantifying Complexity Theory* (2004) may be a more fruitful instrument for future analysis of complex systems (albeit also more difficult to apply). We have used the Lucas (2005) axioms in the following analysis of client complexity, where each subsection will be initiated by a brief quotation (in italics) from Lucas.[9] The objective of the analysis is two-fold. First, to look at the client to see whether all or most of the characteristics can be found in a typical client system, second, to initiate a better explanation for the client's often irrational behaviour (as perceived by construction professionals), which will initiate new ways to cooperate during projects.

General Behaviour of Complex Systems
In our review of the available literature we were unable to find any real attempt to understand the nature of the client, for example, his/her behaviour and his/her whims. As a direct reaction to this lack of relevant material we have confined our analysis in this section to that based on our combined experiences of construction projects. We hope that this, somewhat personal, reflection may help to shape some of the issues associated with client complexity. Readers experienced in dealing with construction clients are invited to reflect on their own experiences and add to the complexity characteristics. The objective

[9] For further studies the reader is invited to visit http://www.calresco.org/lucas/philos.htm (It is suggested that the reader substitute Lucas' term 'part' (or parts) by the term 'participant' (or participants)

is not only to prove that the typical construction client shows all the behaviours expected in a complex system but also to provide a way of understanding client behaviour.

Lucas's axiom[10]	*Summary*	Comment
Non equilibrium	*The system operates far from equilibrium since it takes energy from its environment*	The construction client is a body of persons representing a broad and most often very dynamic group of stakeholders and in this the client brings new ideas into the process all the time. This group of people are in dialogue among themselves and with their constituency. This is both an iterative and a learning process not dissimilar from the design process And as the designers learn and communicate their ideas they influence the agenda and the dialogue within the client community.
Unpredictability	*The system is chaotically sensitive to its initial conditions*	If we understand design as a learning process, it is obvious that the client – from the construction team's point of view – must be unpredictable. You change your preferences along with your learning. Even more important is that small differences in the outset, say in one or a few of the participants' priorities or feelings may lead to a completely different outcome of the whole process.
Attractors	*The system has multiple dynamic attractors — it can be stable for a while, but not permanently.*	This characteristic may be hard to argue but as experienced project managers we have again and again seen that the design brief stabilizes itself, albeit for a shorter or longer period only, after which a search for new different preferences may break out again.
Phase changes	*The feedback may lead to sudden jumps to another (relatively stable) phase*	The above stable situation is often characterized having the client expressing one rather precise understanding of the project, but then all of a sudden we have the client expressing a completely new set of ideas.
Instability	*Over the long term step changes or catastrophes occur.*	This is an interesting – and very important – point of Lucas. In complex systems breakdowns occur and very often learning follows. Some breakdowns may be large, but most are small. Both authors have experienced clients who will not tolerate mistakes. The 'perfect' linear process was sought for and the briefing and conceptual design processes were executed in a very disciplined way. However, when the breakdown occurred later – and it did – it was much deeper than it would have been if small errors had established a learning system. Bak (1996) argues that such behaviour is an integral part of a complex system's nature and that errors in complex systems therefore should be seen as a vital part of the system's learning and thus avoiding catastrophes. Essentially an argument for more open communication and trust between the actors, which should be brought into the design of a better client briefing — and client management — process.

[10] From Lucas 2005

Evolutionary behaviour of Complex Systems

Lucas's axiom	*Summary*	Comment
Downward causation	*A system is made up of its parts — and the parts are affected by the emergent properties of the whole system*	Any client system has a number of sub-clients representing different interests and these sub-clients change their behaviour/requirements as the process progresses: they learn during the process from their dialogue with the other sub-clients and construction professionals.
Co-evolution	*The parts may evolve in conjunction with each other in order to fit into a wider system*	It is often seen, and experienced by both authors, that bringing the different sub-clients together for the purpose of the project may lead to evolution as participants learn about each other. They are essentially a group to serve a common purpose and the project may, if properly conducted, help to bring about mutual understanding and the evolution of group goals. A point explored more fully in Emmitt & Gorse (2003).
Mutability	*Random internal changes may occur in the system*	This is what we should expect whenever dealing with a group of humans. They change their mind and often as a phase transition between two otherwise stable states.
Self reproduction	*The system can replicate itself*	This point deals with the phenomena that we often copy behaviour and operating methods from each other. But it also deals with the fact that a successful client organisation may be copied in the next project just as the project organization may be. However, this not a sure way to another success because of the system's general unpredictability through its sensitiveness to initial conditions, where small differences do not stay small.
Self modification	*Parts can change their associations or connectivity freely*	Our client is a representative of a number of stakeholders and these stakeholders are not just a group of individuals but a network, which along with the process changes its behaviour.

Connective Behaviour of Complex Systems

Lucas's axiom	*Summary*	Comment
Emergence	*System properties are higher level meta-systemic functions of the system*	When dealing with construction clients and understanding the client as a system of sub-clients it is often seen that the interaction of these parts generates the system behaviour just as much as the sum of the individual participants. A heterogeneous group of stakeholders often acts differently from the way they would have behaved on their own.
Non standard	*The system is heterogeneous and allows varying associations over time*	Just one brief look back at the nine-perspective model of the client (Table 1 - three groups of interest in each of three time frames) shows clearly that this characteristic may apply to the client. The groups' conceptualisation of value and their priorities are different and may often be in conflict but may also at some points be shared for a while, e.g. the common interest by the owner and the user in keeping the project on time and budget.

Lucas's axiom	*Summary*	Comment
Undefined values	*The meaning of the system's interface with its environment is not specified at the outset*	This characteristic is interesting in looking at the client. The client as the person or the group of persons making the formal decisions may have explicit values but in their interaction with the stakeholders and environment their values may change quite dramatically as the project develops. Public hearings and the general opinion make the role as client quite undefined when it comes to the issue of values for all the stakeholders that should be represented in the process. Indeed, one may argue here that the client value becomes an emergent phenomenon.
Fuzzy functions	*The overall function (purpose) of the system is co-evolved*	Even though the function of the client may be modelled in the nine perspectives matrix, the role to be played by this undefined agent in the construction process is rather unclear. He is the one to make decisions, but how will he operate in undertaking this role?
Fitness	*The distribution of choices can be modelled using the concept of fitness landscapes*	The concept of fitness landscapes is an interesting one in relation to the design process where the client plays his most important role, as it explains how development processes moves along towards an optimum – a peak – in the fitness landscape but also how the process can be stranded at local optima (Kauffman, 1993, 1995). This is an often seen phenomenon in construction – the client 'falls in love' with one particular solution, which may not be the best one for any other point of view than that the client likes it, which by the way goes nicely with the nature of value.

CONCLUDING THOUGHTS

Even though Lucas' statements about the behaviour of complex systems may not be complete, it can be seen from the brief analysis above that the construction client is a complex system. Irrational behaviour is to be expected and must be allowed for in any design management system. There is, in our view, a need to engage in scientific research into client complexity and the manner in which it colours the decision making process we know as the design and the subsequent construction of buildings. We hope that this paper will go some way in starting appropriate debate, which may lead us to:

- A new understanding of the client-construction system cooperation in the generation of value and how this cooperation should be organized
- A new understanding of the concept of partnering as a learning collaboration between the client and the construction team.
- A new point of view on the architectural competition as an instrument in forming partnerships because the architectural competition in its traditional format has as an underlying assumption that the client's value parameters can be expressed in a document and be interpreted by the architects without further dialogue.
- A new understanding of why the construction sector is not meeting client expectations or, rather, the reason why construction team often acts on their own understanding of value for the client
- A new approach to project management, where value management gets a place in its own right alongside contract management and production management.

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PROJECT COSTS AND INDUSTRIAL BENEFITS: ANALYSING THE TECHNOLOGICAL FUNCTION OF THE SYDNEY OPERA HOUSE THIRTY YEARS AFTER COMPLETION

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Abstract
In spite of its revolutionary approach to design and construction, the industrial legacy of the Sydney Opera House has never been the subject of systematic analysis. Whilst celebrating the genius of his conceiver Jørn Utzon, the literature remains aloof about the building's contribution to the management of construction innovation, the consequent definition of sectoral policies, and the role that public buildings have in their implementation. This paper documents the methodological underpinnings of a recently funded research project, which attempts to fill such a documentary and theoretical gap by seeking answers to questions concerned with the technical, social, political and economic dimensions of the project's performance. The argument of the paper is that most of these answers can be produced by setting up a framework of historical data connecting the various technologies used for the project to a series of building industry cost proxies, and by analysing their dynamics overtime. The theory behind this work is that the value of design is seldom appreciated fully because it is difficult to measure it within the conventional project-based appraisal framework. The research makes an attempt to reach a better balance between project costs and future benefits by extending the scope of the analysis to the industry at large.

Keywords: Design value, project performance.

INTRODUCTION: DIVIDE TO UNDERSTAND

A common way to assess the social and economic value of design is to look at how the output of the construction sector responds to current and future demand for space (both public and private) and, in the process, generates (by-and-large monetary) wealth for the parties involved. This paper, by contrast, argues that a different approach to the quantification of design value is possible - one that looks at the ways in which the intellectual capital produced through individual buildings is captured by and disseminated through the industry as a whole. This stance seems necessary to counter (or clarify) established positions about low productivity in construction. Though it is true that the 'unit of work / unit of output' ratio in building is lower than it is in other sectors of the economy, it is also true that building is one of the most inventive sectors, since its product innovation cycles are often carried out within the length of the procurement process. This length is shorter than the development timeframe for new products in manufacturing, and has far less resources available. Productivity critics, however, are at least partially right in their accusations, in that buildings are also wasteful repositories of intellectual labour: they require constant problem-solving but generally resist attempts to catalogue it, let alone make it public. Low productivity, in this case, means limited ability to build – pun intended – upon past experiences.

The reasons for this less than optimal use of human ingenuity and technical capital are at least two. One rests on the idiosyncratic, project-based nature of building, which does not facilitate the automatic transmission of knowledge; the other on the predominance of what Marian Bowley called the 'contracting system', and the temporary project coalitions such system gives rise to.[11] This second characteristic determines the sensitivity as well as the confidentiality of much of the work carried out, which increases in proportion to the degree of complexity (and therefore likely innovativeness) of the project. Interestingly, this condition exerts a particularly negative effect over large public institutional work - a section of the building industry that should be, at least in principle, more inclined towards introducing and disseminating innovation.[12] Instead, in situations where the control of current expenditure is more important (or easier to convey) than the future value of the investment, public administrations are reluctant to promote or advertise innovative building pilots and solutions (often associated with marginal costs, increased development uncertainty and targeted industrial action), especially when the profile of the project does in fact generate public scrutiny over its management. As a consequence, the official narrative of much building work, particularly the most interesting one, tends to be more rhetorical than factual; it impinges on what can be said and made publicly known without risk rather than what really happens. Building scholarship becomes one of the victims of this state of affairs. With limited access to documentary sources, it is often developed more through the administration of questionnaires than the scrutiny of project records, by asking managers rather than working the proverbial fields. Yet the desire to enter the details and dynamics of project innovation is not trivial. The success of strategies developed at an industrial level needs to be verified at the level of individual building projects - which is how the industry works - rather than statistically. Without proper records at a small scale it is very difficult to derive, establish or monitor paths of technological development and dissemination at a large scale. The problem thus persists: How can the industry capture the lessons learnt individually and use them to advance its own collective cause?

The thesis behind the present contribution is that, for this to be done effectively, it is necessary to employ building case studies as sources of detailed information whilst disentangling the analysis of technology from the analysis of the individual project (and the performance of its project team members). This strategy is believed to produce a double benefit: on one side, it does not fully enter the sensitive aspects of the contracting system, thus making the collection of data easier; on the other, it treats the data collected as the reflection of the specific use of an industrially available set of technologies rather

[11] See: Bowley, M. 1966. The British Building Industry, University Press, Cambridge; Ive, G. and Gruneberg, S. (2000), The Economics of the Modern Construction Sector, MacMillan Press, UK.

[12] As I have explained in previous discussions on the social value of buildings, there are at least five reasons for which large public structures should be considered ideal innovation test beds: (1) their commissioning bodies are in a position of operational strength; (2) they are often developed not only to respond to a specific need but also to institute collective values; (3) their representational power and ad-hoc programmatic requirements combine to balance the otherwise common search for cost-cutting strategies in construction; (4) the promoting agency has no interest in securing market advantages through innovation and is rather interested in its diffusion; (5) they are large in size, thus affecting the length of the development process and producing a larger-than-average time capsule within which multiple product development cycles can be started and completed. [Tombesi 1999, 2004]

than a one-off experience, thus bringing single buildings and building production together.

A CASE (STUDY) IN POINT: THE SYDNEY OPERA HOUSE

The Sydney Opera House (1957-1973) is an ideal case study to articulate this thesis. To start with, it is a very large, visible, and public building artefact which defines, in many ways, the image of contemporary Australia. In light of its scale, program and lack of precedents, it is commonly acknowledged as an important laboratory for building innovation. The work of many leading architects of the current generation owes a direct debt to the Sydney Opera House. Yet the procurement process generated a great deal of controversy, including the dismissal of the original architect, Jørn Utzon, and his replacement in 1966 with a team of government architects: Ted Farmer, Peter Hall, David Littlemore and Lionel Todd.[13] Moreover, its development procedures and results, as well as its costs and eventual benefits, are still subject to contrasting evaluations.[14]

As several commentaries have shown, the building was used politically, during its construction as well as after its completion, to denounce budget allocations or spending policies. It may have thus contributed significantly to the development of an institutional position about innovation, and affected future policy-making decisions with regard to planning and control of public buildings and expenditure. Yet in spite all this, the industrial legacy of the Sydney Opera House has never been the subject of systematic analysis. Whilst celebrating the genius of his conceiver Jørn Utzon, the literature remains aloof about the building's contribution to the management of construction innovation, the consequent definition of sectoral policies, and the role that public buildings have in their implementation. As Peter Murray [2004] suggests, the public history of the Sydney Opera House is a tale of individual heroes and villains embedded in myth rather than a history of collective accomplishments and long-lasting contributions. Architectural writing has largely concentrated on the building's relationship to its author and client, whereas government literature has remained largely silent on the entire process. Consequently, the scholarship available is limited to either a few, architecturally significant items – the glass walls, the plywood cladding, the hall interiors, the roof shells - or the architect's *cause célèbre* during the first nine years of the project (1957-66).[15] The rest remains disjointed and anecdotal. Official publications maintain that the building was groundbreaking but we don't know the detailed scope or the import of its discoveries. We know that some companies benefited enormously from their association with the Sydney Opera House

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[13] Utzon's original design for the Sydney Opera House consisted of three main elements: a large podium, upon which rested three series of sheltering shells, with the theatres nestled underneath. The construction of the building essentially followed this progression. Stage I (1959-1962) saw the site cleared and the construction of the podium, Stage II (1962-1967) primarily involved the design and erection of the shell structures, Stage III (1967-1972) concerned paving and cladding, the glazing of the open ends of the sails, roof shell interior and building fit-out. In 1966, after the podium was built and a year before the completion of the roof shells, Utzon resigned over conflicts concerning changes to fundamental management and work procedures.

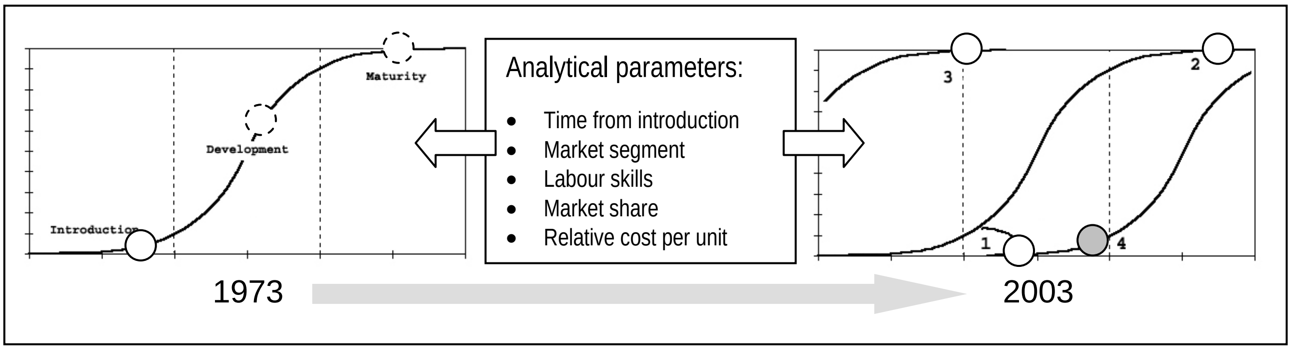
[14] See, for instance, the completely different accounts provided in *Technology in Australia 1788-1988* [AATSE 1988] and *What made Gertie gallop: lessons from project failures* [Pinto and Kharabanda 1996].

[15] See for example: Fromonot, F. 1998. *Jørn Utzon architetto della Sydney Opera House*, Electa, Milano, Italy; Drew, P. 1999. *The Masterpiece – Jørn Utzon: A secret life*, Hardie Grant Books, South Yarra, Victoria; Drew, P. 2000. *Jørn Utzon and the Sydney Opera House: as it happened 1918-2000*, Inspire Press, Annandale, NSW.

while others waited years to reap any benefits from it, some stagnated and others went into receivership. Yet we don't have a way to examine the dynamics by which this happened. We know that technology was copiously transferred in and out of the project: glazing joints, for instance, were imported from the aerospace industry while internal roofing connections were exported to offshore oil drilling platforms. Yet we don't have a map to trace and compare all these exchanges.

SEPARATING MASTER AND PIECE

In 2004, I was awarded an Australian Research Discovery Grant to produce such a map.[16] Specifically, I wanted to see whether one could systematically: 1) analyse the type and amount of technical knowledge produced through the development process of the Sydney Opera House; 2) examine how this knowledge has been utilised after the project's completion; 3) determine whether it generated industrial value for Australia, the Australian construction sector, or the parties involved in its development. The problem, however, was being able to move beyond the mythological dimensions of the Opera House (both positive and negative), and examine its mostly undocumented building reality. A decision was made to start from two sources kept in the New South Wales State Records Archives: the 'Green Book', an index of the project's technologies produced by the state government architects right after the completion of the third and last construction stage of the Sydney Opera House [PWD 1973], and a list of project participants issued by the general contractor Hornibrook at the same time [Hornibrook 1973]. The two documents dissect the scope of the project into its technical and social components: approximately 400 individual items (building systems, components, materials, management procedures) and 165 business entities (agents, contractors, sub-contractors). This contractual deconstruction provides an opportunity to look at the building as a large kit of heterogeneous parts, from the point of view of the industry rather than the exclusive points of view of the architect or the client.



The plan of the research, currently in its early stages, is to establish how innovative each of the items listed in the 'Green Book' was at the time of its procurement, and how it has evolved since. As the above figure explains, one practical way of accomplishing this goal is by determining the original and current position of the related technology along the s-

[16] Paolo Tombesi, "From tourist siren to technological beacon: Analysing the industrial function of the Sydney Opera House thirty years after its completion", 2005 Australian Research Council Discovery Project Grant DP0557617.

shaped curve of classic innovation diffusion theory: at the bottom (introduction), on the rise (development), or at the top (maturity) [Rogers 1971]. This can be done by using (separately or in combination) five construction proxies available through trade literature and statistics, industrial bodies' reports, and costing manuals: time in existence of the technology, market segment, type of workforce required to develop and implement it, diffusion as compared to available alternatives both in Australia and overseas (based on percentage value of the trade in the market and building share), and relative cost per unit.[17] The picture obtained by using 1970s information can thus be compared to the picture produced by using current industry data. Each comparison entails four possibilities: (1) the technology did not move along the curve (i.e. it didn't take off and has been discontinued); (2) the technology reached its stage of maturity (and was therefore successfully introduced); (3) the technology stayed at the same level (i.e. it had already 'plateaued'); (4) the technology has been superseded by another one (i.e. it became obsolete).

When extended to the entire 'Green Book' index, this exercise enables one not only to assess the overall degree of 'stability' or 'instability' of the set of technologies employed in the Sydney Opera House, but also to describe the breadth of innovation of the building. The items in the list, in fact, can be grouped into various sub-sets of product-related and process-related technologies. Articulation and size of each sub-set indicate whether innovation concentrated in particular areas of design and construction or took place across the spectrum.[18]

Once the scope of the original work is established and the diffusion of the solutions adopted assessed, attention can be directed towards the companies involved with the Sydney Opera House at any point between 1957 and 1973. To start with, it is necessary to determine the success of each contract in relation to the nature of the specific assignment. This can be done through archival research by combining three types of sources: (1) company-specific information from the 1973 index; (2) individual contract documentation and the related correspondence files held in the NSW Records archives; and (3) contract maintenance history available with the Sydney Opera House Trust.
The completion of this task will produce a record of the type of technology, its eventual diffusion in the market, and the original performance on the job of the company in charge of it.

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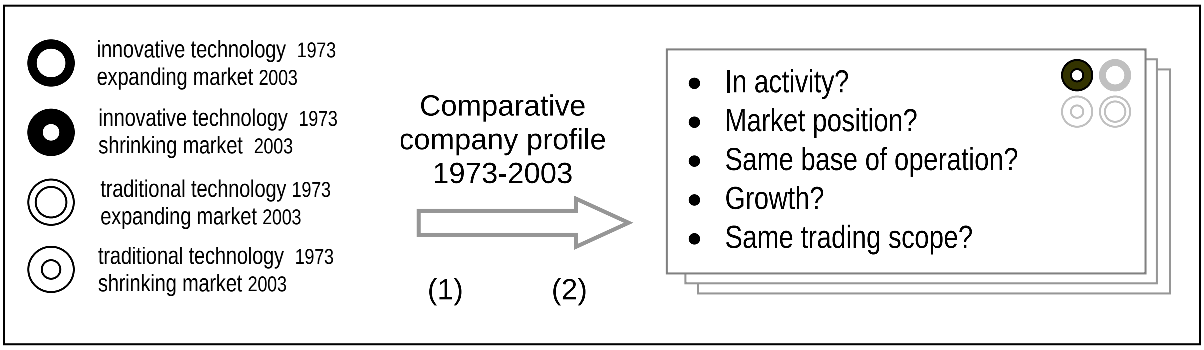
[17] In essence, these figures reflect the level of cultural embeddedness and market acceptance of each of the solutions employed at a given time.

[18] Product-related technologies comprise all the physical devices used to define, manufacture and assemble the building: spatial configurations, building systems, building materials and building equipment. Process-related technologies relate to the activities and social agreements that underlie actors' participation: (a) methods of actors' selection and contractual engagement; (b) systems of design simulation; (c) communication and transfer of decisions; and (d) decision implementation and work monitoring procedures.
(Technologies no longer in use may entail an exchange with representatives from the specific trade to determine what factors contributed to their demise: cost, technological obsolescence, lack of competitiveness, industrial barriers, or changes in legislation. Technologies showing much improved diffusion are likely to be subject to the same process with different parameters: standards of performance, production breakthroughs, composition of market demand, institutional push.)

The next step is to locate each company and ascertain its current status: whether or not it is still active, its position in the industry, base of operation, size, business concerns, trading arrangements, and work methods. As the next figure indicates, data can be organised statistically in simple binary fashion: In business or not? Industry leader or not? Same base of operation or not? Smaller or larger? Broader or narrower scope? Trading independently or as a subsidiary?



At the end of this stage it will be possible to determine whether the companies that dealt with innovative technologies at the time of construction have developed a stronger position in the market or suffered from the project's setbacks, or whether their industrial evolution was independent of the role played on the Sydney Opera House. In some cases, it may be necessary to check for methodological continuity between the work carried out on the specific project and current work. This is because it is critical to discern whether the lessons learnt or the experience gained on the Sydney Opera House were developed or re-used. If so, how did the company manage to store the relevant information? Same as with technologies, the companies' database can be organised by sub-groups - professional consultants, general contractors, trade specialists, manufacturers and materials suppliers - to see if any industrial patterns emerge according to either sociological categories or technical specialisations.

The last part of the research involves the analysis of the employment trajectories of a significant sample of skilled workers (selected from the 'Green Book', the Hornibrook publication and individual tender submissions filed in the State Records archives, based on the positions this workforce occupied within the project team). The aim of this task is to make sure that the possibility for informal transfers of knowledge is verified, and a preliminary assessment of its impact made.[19] To this end, the post-Sydney Opera House careers of approximately two hundred people are being researched (to be eventually organised into a synthetic, one-page template profile within a database) by relying on the firms' contacts acquired earlier, and trade or professional memberships. What did all these people do after the completion of the project? Did they stay with their companies or move on? Which other projects were they involved with afterwards?[20] At this point, each

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[19] This task responds to Nam and Tatum's thesis that construction innovation needs leaders and champions internal to the project. See: Nam, C.H. and Tatum, C.B. 1997. Leaders and champions for construction innovation, *Construction Management and Economics* 15:259-270.
[20] Even in this case data will be organised by sub-groups: designers, executors and commissioners, further divided into facilitators/planners, technical designers, managers, specialised erectors, manufacturers and regulators.

one of the 400 items of the ‘Green Book’ index will be linked to its industrial performance over thirty years, the company (or companies) that developed it, selected individuals that worked on it, and other buildings that employed it. The resulting inventory can be examined in light of enumerable variables - sensitive systems successfully introduced, technologies brought to maturation, research spin-offs, company take-offs, legislative acts, etcetera - and be used to structure comparisons between the Sydney Opera House and other buildings, or to identify specific issues, companies or decisions in the life of the project that warrant further detailed study or verification. It can also be employed to undertake multivariate analysis aimed at determining whether or not, within the experience of the Sydney Opera House, statistical correlations can be drawn between technologies, policies, types of companies, and workforce development.

BEYOND GOOD INTENTIONS

The research program started a few months ago. The amount of data collected to date is therefore relatively limited: whilst most of the original firms (98%) have been tracked down, the comparative analysis of the technologies employed is still being carried out, and has been completed only for a few ‘pilot’ trades. Interviews with some of the actors involved and industry representatives have also been conducted, but a great deal of archival research and primary sources analysis still lies ahead. Yet, though it is too early to draw definite conclusions about the eventual findings of the project, it is possible to offer several considerations based on the work developed thus far. To start with, there is no doubt that the procurement process of the Sydney Opera House generated ample opportunities (as well as strong need) for unprecedented technical contributions, offering professional consultants, contractors and trade specialists a chance to work on turbulent technologies and develop cutting-edge expertise. The design, engineering and management activities carried out during and after Jørn Utzon’s tenure brought about and verified the validity of new labour practices, site erection strategies, system assembly techniques, mechanical systems configurations, environmental policies, and more. Aside from its well-known structural solutions for the shells and amongst other applications, the building was the first of its kind in Australia to use computer-based three-dimensional site positioning devices, geothermal pumps, tower cranes, chemical anchors, non-competitive tendering, life-cycle engineering, parametric design, and critical path methods. It created the need for new consulting entities such as Unisearch, the testing laboratory at the University of New South Wales, which became one of the first organisations in the world established to commercialise university research and support technology transfer. It helped certain companies build profile and expertise that would be used around the world. It also allowed international firms such as Arup, Freyssinet, Haden Engineering, Stenseen Varming and others to plant the seeds for their future strong presence in Australasia. Today, at least ten of these firms feature the skyline of the building in their logo to imply direct lineage and suggest a sense of specific, challenge-driven quality in their work.
Yet the overall industrial picture is different. Out of the 165 companies listed in the ‘Green Book’, 68% still worked in 2002. Of the 52 no longer trading, 63% were subcontractors, 33% producers and suppliers, and 4% professional entities. The group of subcontractors included for the most part family-run businesses; 75% of producers and suppliers dealt with building materials no longer in use and 25% with sophisticated components. Half of the companies still trading have been incorporated in companies of larger size and market. Professional firms have resisted industrial consolidation better

than any other group. In particular, the Australian branches of international specialised consulting groups have done well. Australian companies, by contrast, do not appear to have benefited greatly from their participation in the project, with the exception of those enjoying an already solid reputation or occupying quasi-monopolistic positions in their product niches, or those bought out by foreign entrepreneurs - such as Permasteel, which eventually became Permasteelisa.[21]

In terms of technologies' introduction and diffusion, the effective application of innovative solutions did not automatically result in industrial dissemination or commercial success. In several cases, the unique production requirements of the Sydney Opera House - combining simulation abilities with precise on-site manufacture and advanced production-and-control technologies, and careful monitoring of construction progress with close checking of tolerances - hindered the diffusion of the solutions arrived at. The bar was either set too high (or positioned too idiosyncratically) for the rest of the industry to jump over it. This happened not only for the post-tensioned segmental concrete structure of the sails, or the ad-hoc erection equipment necessary to position the elements in place. It also affected simpler systems. The exposed granite aggregate adopted for the pavers of the monumental podium, for example, was cast on-site by using a specially-designed rig, which allowed rigid tolerances and resulted in very low rejection rates. Yet, since the nature of most construction sites makes on-site casting and storage difficult, the technique was hardly reused. Air conditioning provided similar opportunities for product development, only partially exploited thereafter. Utzon's requirement for the elimination of cooling towers from the roofline of the Sydney Opera House combined with the position of the building right on the harbour to suggest the installation of a geothermal heat pump that took advantage of the seawater surrounding the complex as a heat sink. Generally only used in the power industry until then, the solution was immediately adopted by other buildings in the Sydney water ferry station area but employed only sporadically in the following years. Heat pumps, however, have recently been gaining popularity as one method for achieving more environmentally sustainable architecture.

Some technological dissemination occurred across sectors. The epoxy resin used as a structural adhesive to hold the segments of the ribs together before post-tensioning, for instance, had until then been used to bond metal plates to concrete railway sleepers or glue concrete curbs to road surfaces. In building, only the structure of the Coventry Cathedral (Basil Spence, 1950-62) had resorted to it, but for simpler connections. Its adoption for the Sydney Opera House produced a large amount of research on its structural resistance as well as application techniques. To counter the possibility of structural movements during the settling period, lateral stressing cable anchors were employed that used K-Monel, a copper-nickel alloy highly resistant to corrosion. Following prolonged testing for fatigue and heat resistance, the mechanical and chemical characteristics of the material were communicated to the rest of the industry in 1966. Today, K-Monel is used predominantly for oil drilling platform and gas production equipment.

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[21] The Australian Permasteel merged with the Italian ISA in 1985, after a few years of collaboration, and following Permasteel's difficult financial position in the period after the completion of the Sydney Opera House.

By collecting and analysing these and other stories, one gets a sense that - in spite of its importance in the history of architecture, engineering and construction, and because of its conceptually radical nature - the Sydney Opera House worked selectively as a seed for technological innovation or industrial growth. The project provided unprecedented opportunities for the industry to analyse and transform its procedures but also generated a political backlash, which made the institutional support of innovative local companies difficult, and the markets reluctant to embrace the innovation produced, especially when this required labour upskilling and technological restructuring. As a result, many of the experiments carried out were not followed through after the completion of the project, and much of the groundbreaking technology successfully developed because of it either lay underutilised or was acquired by foreign companies. Moreover, State and Federal governments enacted a series of procedural restrictions and limitations to building procurement routines, thereby engendering an administrative culture that resulted in the reduction of public buildings' potential to act explicitly as innovation laboratories, unless such innovation led directly to immediate cost savings and increased development control.[22] Yet if one looks at the legacy of the project (or the experience that emanated from it) thirty years later, the picture is once again different. Today's industry has accepted and widely adopted many of the controversial design and management methods originally employed in the Sydney Opera House under Utzon: *de facto* pre-qualification of bidders, use of scope drawings, performance-based design assistance from trade specialists, horizontal transfer of technology from other sectors, mock-up testing, and on-the-job skill development. The practice of high-end architects such as Renzo Piano, Norman Foster and Frank O. Gehry cannot be fully understood without considering the impact of the building's lessons on their architectural formation and eventual methods of practice. Even the general discussion on construction reflects its prophetic lessons. The literature produced over the last 20 years in such think-tanks as the Centre for Strategic Studies in Construction at the University of Reading or the Imperial College in London, or through research fellowships such as the Latrobe program of the American Institute of Architects, has been describing the optimal connection between technological complexity and social networks by using models that could have been derived almost directly from the managerial analysis of the Sydney Opera House.[23] Last but not least, the official

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[22] Because of its immense cultural resonance, the experience of the Sydney Opera House can be easily connected to the emphasis heretofore placed (not only in Australia but worldwide) on efficient building delivery, the importance of brief writing and program definition, the introduction of stringent cost control techniques in construction, the rise of non-architectural project management roles, the reorganisation of major design competitions in two stages, the resolution of internal conflict within project teams, and the minimisation of industrial action potential. See my "Back to the Future? The Pragmatic Classicism of Australia's Parliament House", in *Architectural Research Quarterly* 7/2 (2004): pp. 150-164.

23 See for example: Gann, D. 2000. *Building Innovation: complex constructs in a changing world*, Thomas Telford, London; Bennett J., Ferry D., 1990. Specialist Contractors: A Review of Issues Raised by Their New Roles in Building, *Construction Management and Economics*, 1990/8:259-283. Gray C., Flanagan R., 1989. *The Changing Role of Specialist and Trade Contractors*, The Chartered Institute of Building, Ascot; Gray C., Hughes W., Bennett J., 1994. *The successful management of design: a handbook of building design management*, Centre for Strategic Studies in Construction, University of Reading; Kieran S., Timberlake J., 2004. *Refabricating architecture: how manufacturing methodologies are poised to transform building construction*, McGraw-Hill, New York.

policies for building work of many public bodies, including the Public Works Department of New South Wales - the original Sydney Opera House client – now reflect a different, more accommodating position towards the organisational principles the building was imbued with.

EMERGING LESSONS AND OPEN CONCLUSIONS

For obvious reasons, the conclusions of this paper cannot be concerned with the conclusions of the research but rather with the value of producing analyses of this type. The multiple views contained within this summary of the initial work indicate the existence (or the possibility) of different and yet equally valid design appraisal scenarios, sometimes in open contradiction with each other but all necessary to get a proper picture of the industrial relevance of the building. They would not have emerged unless one went down the path outlined. Their very definition, on the other hand, suggests that the evaluation of structures such as the Sydney Opera House must not only be multifaceted but also involve different timeframes. Depending on how one looks at it, the building can be interpreted as a socio-technical laboratory, a technological precursor, a negative determinant of public policies, a positive harbinger of change, and a generator of firms' internal capital. Its industrial evaluation in each category is different – turning it into an asset or a liability for those involved, and changing drastically in relation to the time span adopted. The longer is this span, the more influential is the building, the less relevant its initial costs, the broader its industrial significance.

The lessons we can draw from it are also multiple. At one level, the Sydney Opera House shows that individual buildings can provide fertile grounds to plant industrial development seeds but that, in order to have a real impact on the structure of the local industry or economy, they must respond to or acknowledge specific structural conditions, be preceded by the explicit definition of industrial policies, and possibly be supported by political determination. At another level, it clarifies that the development of both, buildings and policies, requires not only a long-term perspective but also an institutional understanding of the relationship between cost and investment in construction. For this understanding to be developed, the analytical approach supported in these pages seems to offer a viable operative strategy, at least for public (or however institutional) buildings. Once we accept the rationale for this type of work and recognise its validity, we can also start understanding its applications. In this sense, the 'industrial' analysis of significant project case studies could become part of the methods employed when monitoring public building expenditure. The Australian General Auditor's reports on public capital projects, for example, which are traditionally concerned with procurement costs rather than technological investment opportunities, may be extended to incorporate a thorough analysis of buildings' expected contribution to their industrial environment as well as a justification for the public support of the strategically or environmentally valuable research possibly carried out by the firms involved.[24] The same methodology could also

[24] To get an idea of the current focus of auditing reports in Australia, one can look at the documents produced for the Federal Parliament House [Auditor-General 1987, 1990; PHCA 1990], the National Museum of Australia [Commonwealth of Australia 2000], and Federation Square [Victorian Auditor-General's Office 2000]. It would be useful to consider the auditing approach vis-à-vis David Gann's discussion in: Gann, D. 1997. Should governments fund construction research? *Building Research and Information*, 25 (5):257-267.

be employed to assess, comparatively, the industrial value generated by different public buildings in the domestic sector or vis-à-vis similar projects overseas.[25] The information gathered through these exercises would form the basis from which a national policy on construction innovation could be developed.

But if the advantages of the research product are plentiful, the agencies in charge of producing it may not be. This type of work, in fact, requires the ability to muster a broad area of expertise as well as to occupy a position of industrial neutrality. As a form of advanced public scrutiny, it must be carried out by institutions that sit outside specific interests, and are apt at making connections and adding complexity to the area of analysis rather than keeping issues separate and simplified. Universities, and even more so research-based organisations that rely on the human and technical capital of the former for non-commercial purposes, stand as obvious and necessary choices in this regard. The call to combine building and industrial scholarship, then, amounts to more than the need to assess the design value of determinate structures. It also reinforces the critical function that institutions such as CIB can and should play in bringing this task to fruition.

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[25] Festival Centre in Adelaide, the Arts Centre and Federation Square in Melbourne, the Federal Parliament House and National Museum of Australia in Canberra, and the Olympic Games infrastructures in Sydney are examples of other public building experiences in Australia that could be useful to compare.

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COMMUNICATING DESIGN

A THREE LEVEL APPROACH FOR EXPLORING ICT IMPACT ON ARCHITECTURAL DESIGN AND MANAGEMENT APPLIED TO A HOSPITAL DEVELOPMENT PROJECT

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Abstract
An understanding of how ICT impacts the building design process and the architect's role and contribution within it can be crucial for ensuring good architectural design and management of building projects. This paper is based on a possible approach of organizing and structuring design process actions and roles, and how ICT impact on them. The approach is founded on the recognition of three levels within the building design process and focuses especially on four essential, interdependent and iterative aspects: the generation of design solutions, the communication, the evaluation of design solutions and the decision-making. This approach aims to contribute to a better overview of how ICT impact the building design process in general, and the architect's role and contribution in special. The purpose of this paper is to illustrate how this approach can be used to explore several architects' experiences due to use and implementation of ICT in a large hospital development project in Norway. The main experiences regarding the ICT implementation and use are summarized within an ICT impact matrix.

Keywords: ICT impact, architectural design and management, three level approach

INTRODUCTION
A fundamental pillar of a successful building project is a good design process. The future and development of a good architectural design solution depends on complex and iterative processes on several levels and with different actors (Lawson 1997). Over the years, the ICT (information and communication technologies) impact has led to dramatic changes within the construction sector average working day, affecting both processes and roles (Wikforss 2003). The participants within the building design process face ICT related benefits and challenges at several levels. On the international IAI (International Alliance of Interoperability) conference "BuildingSMART" in Oslo June 2005, one of the key-themes was the ICT related paradigm shift within the AEC sector and which threats and opportunities this shift inherits for the architect. The architect has traditionally a distinct and important role within the building design process (Gray & Hughes 2001). His skills makes him adaptable for several roles, from being a design specialist, translating the many project constraints into physical form, to being involved with management tasks; leading, coordinating and administrating the design process as the building design- or even the project manager. Although the traditional leadership role of the architect within these management tasks partly has passed to other management oriented professions (Emmitt 1999). An understanding of how ICT impact the building design process and the architect's role and contribution within it can be crucial for ensuring good architectural design and management of building projects.

This paper is based on a possible approach of organizing and structuring design process actions and roles, and how ICT impact them (Moum 2005a; Moum 2005b). The approach is founded on the suggestion of three levels within the building design process and focuses especially on four essential, interdependent and iterative aspects: the generation of design solutions, the communication, the evaluation of design solutions and the decision-making. This approach aims to contribute to a better overview of how ICT impact the building design process in general, and the architect's role and contribution in special. The purpose of this paper is to illustrate how this approach can be used to explore several architects' experiences due to use and implementation of ICT (especially an IFC-based 3D object model) in a large hospital development project in Norway. This is one of the first attempts of applying the approach to a real-life building project. The resulting first and tentative impressions of the approach's adaptability on practice are intended to establish a basis for further development of the approach.

After a short description of the project, the three-level-approach will be explained and the four interview respondents introduced. All respondents are architects involved in management tasks on different levels in the project. The main points from the interviews regarding the implementation and use of ICT will be explored and described. The interview respondents' perception of the project processes, participants, and the use and impact of ICT, can deviate from how something really happened. Also, the intention of this paper is not to cover all aspects which came up during the interviews, rather some of the key points will be described to illustrate and discuss the adaptability of the approach on practice. At the end of the paper, an ICT impact matrix summarizes these key points (Table 1). This paper and the three-level approach contribute to a framework for further inquiry about the relation between ICT and the architect's role and contribution within design and management of building projects.

INTRODUCING THE REAL-LIFE PROJECT: AHUS

The new Akershus University Hospital (AHUS) is a major hospital development project in the suburbs of Oslo, Norway. The new hospital buildings comprise a total floor space of 116.000 m2 (Figure 1). After an architectural competition and several revisions, a final main outline of the project was presented in May 2003, and this outline became the basis for further design development and detailing. Full operation is planned during the autumn 2008 (www.nyeahus.no). The architect suggested early to implement a 3D object model (building information model or BIM) based on IFC (Industry Foundation Classes) and intelligent objects. The client's "go" for this suggestion, made the AHUS project to what Khemlani (2005) calls "*a front runner in Norway in the use of IFC-based BIM*". The project is divided into five main building parts, with their own teams of architects and consultants. The 3D object model has to a different degree become implemented in the five building parts. Only the architectural team developing and planning the front building uses the 3D object model to (almost) its full extent. This paper focuses on this front building part (2.500m2), which contains the main entrance, an auditorium and a cantina (Figure 2). The modelling of the front building started autumn 2004, and in the spring of 2005 the 3D object model was "completed", a little later as expected. Summer 2005 the front building project is going to be handed over to the contractor and the production of the building starts. All key participants of the total building project work collocated directly beside the building site.

The four ICT cornerstones of the project and some of the visions behind them
There are four ICT cornerstones in the front building project. Firstly, the 3D object model (AutoCad ADT 2004) which: *Given the huge size and complexity of the project (…), the main focus of the use of BIM was to keep track of all the objects—rooms, components, fixtures, furniture, and equipment—not just during design and construction but throughout the project lifecycle* (Khemlani 2005). This paper focuses mainly on the implementation and use of this 3D object model. According to the contract, the 3D object model is the property of the client. Secondly, in a document database (ProArc) all drawings and documents are archived and distributed, no parallel document archiving is allowed. Up-to-date project material is accessible to every project participant, independent of time and place and without the danger of working with or discussing obsolete material. Thirdly, a room database containing room lists, equipment lists etc. represents the users programme and requirements (dRofus). And finally, e-mail is an important tool in the everyday project communication. IFC-based BIM could eventually become a standard building process tool in some years, and an essential aim for using this tool within AHUS, is to collect experiences and build up competence around the implementation and use of this still quite new and untested technology within the AEC sector. Against the original intention comprising both architects and consultants, only the architect work directly with the 3D object model. Three IFC R&D projects are going to be and partly are implemented and tested within the planning of the front building. An IFC Model checker (Solibri) can check the consistency of the 3D object model through intersecting objects, doubles- and clash-detection etc. Another project is the linking of the room database with the 3D object model, with the possibility to check deviations between the users requirements due to rooms and equipment, and what is actually integrated in the object model. The last project is to transfer object information to Facilities Management (FM) systems (Bakkmoen, BuildingSMART conference in Oslo, 31.05.-01.06.2005). An open question in the project today, is to which extent the contractor will implement and use the 3D object model in the further realization of the project.

THE THREE LEVEL APPROACH AND THE INTERVIEW RESPONDENTS
Three levels of operations and actions within the building design process are suggested. The micro-level comprises individual and cognitive processes, as the creative processes in the head of the individual architect. The meso-level covers the mechanisms within a group, for instance the architect's interaction with other designers and consultants within the design team. The macro-level comprises tasks and mechanisms on overall organizational or project level (Figure 3), as e.g. architectural or project management (Moum 2005a).

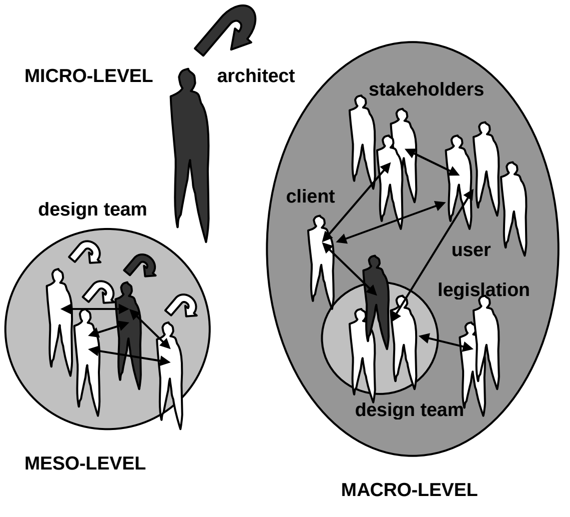

Figure 1 (left top): The new Akershus Universtity Hospital (from: www.nyeahus.no)
Figure 2 (left bottom): The front building (from: www.nyeahus.no)
Figure 3 (right): The three hierarchical levels

All four persons interviewed are architects, involved with management tasks on different levels and within different contexts.

Respondent A: female architect, employee of the architectural company, 20 years practical experience. Her main tasks are the individual generation of design solutions regarding the front building interior (micro-level) and the development and coordination of these design solutions within the design team (meso-level). Since she is the vice manager of the architectural team, she also to some extent takes part in the discussions with users and clients (macro-level).

Respondent B: male architect, employee of the architectural company, 9 years practical experience. He has the formal responsibility of managing and representing the architectural front building team (meso- and macro-level), in addition (since the team only comprises three persons) he designs and develops the front building envelope (micro-level).

Respondent C: male architect, employee of the architectural company, 27 years practical experience. He is the vice building design manager for the total project from the architect group, responsible for the administration of the work processes and the production of planning material (macro-level). He is also the key-person behind the overall project systematization and the implementation and development of the 3D object model and the R&D programme.

Respondent D: male architect, employee of the client organization, 24 years practical experience. He is one of five project managers, with responsibility for the planning part of the overall building project and the management of the contracts with the architect and the other consultants (macro-level).

The data from the interviews are intended to give a rough picture of how ICT impacted on all levels and all four design aspects, thus demonstrating and illustrating how the approach can be applied to a real-life project. Therefore interview respondents were selected representing experiences perceived from different levels, views and positions within the front building project. Respondent A is a frequent user of the 3D object model, without a direct influence on the implementation and development of the model. This is the responsibility of respondent B and C, who both administrate and facilitate the implementation of the model in the front building team and on project level. Respondent D has no special knowledge about how to use or develop the technology, but as a client he has strong and obvious interests in a successful implementation leading to a successful building project.

AHUS: USE AND IMPLEMENTATION OF ICT ON MACRO-LEVEL

On macro-level there are formal structures for communication and decision-making. Regularly there are arranged meetings for different purposes (every 1-2 weeks). The front building planners meeting is the operational instrument of the project. Every decision regarding the design and development of the front building is made here. The participants in these meetings are, in addition to a person representing the user and the client (project part manager), the responsible persons from the different building planning disciplines. Thus, both respondent A and B participate in these meetings. Another meeting forum is the total project meeting, which focuses on strategic and administrative aspects due to the total project. Meeting leader is the respondent D. Respondent C participates in some of these meetings as a vice leader of the architectural discipline. Finally, the future users of the new hospital have a central position in the definition of requirements. The extensive degree of user participation required regular meetings between the users, clients and the planners during autumn 2004.

Macro-level experiences from implementation and use of ICT- some examples

The 3D object model is not used directly in the formal meetings. Evaluation of the project development and decision-making are based on views or cut-off drawings (2D) generated from the model, partly projected on a screen using a beamer. In the total project meetings, every participant brings their own laptop. Once a week a cut-off of the 3D object model is laid out into the document database, thus every relevant and up to date drawing or document is easy and fast accessible, which respondent D regards as a huge advantage of ICT. In comparison, within the front building planners meetings the pen, sketch paper and physical models are still central tools supporting ad hoc solution generation and decision-making. Regarding the user meetings, the 3D object model became a valuable support for preparing discussion and decision-making material. Around 1000 unique rooms on total project level made a huge amount of drawings necessary as basis for the discussions and decisions. All these drawings (sections, plans and elevations) were generated directly from the 3D model.

An interesting aspect, which came up in the interview with respondent D, was the rigidity of the ICT tools regarding presentations. He perceived that perfect, static and almost finished looking drawings and illustrations presented in the meetings did not lead to dynamic, open and flexible discussions. Rather the presentations paralyzed the meeting participants and made it difficult for them to suggest changes.

The implemented IFC based 3D object model version does not support rendering of the objects. Thus, it is not possible to generate realistic visualizations and walk-throughs directly in the 3D model environment, which could be used for more dynamic and interactive presentations of design solutions in e.g. the users meetings. However, the 3D object model of the front building has now reached a stage where calculations and simulations regarding indoor climate, energy consumption etc. are possible. But the model is “heavy” to use and change in this late stage of design. Therefore, to work directly in the 3D environment in meeting situations demonstrating e.g. “live” simulations seems to remain being difficult since more rapid simulations or visualizations of results are required.

From the client’s view (respondent D) ICT offer good possibilities for better could follow, control and evaluate the development of the planning. Cut-offs and the viewer technology make the access to the 3D object model easier. However, respondent D perceives the model being a black box to which the client has no directly access, unless he has special ICT competence. In this project, this drawback of ICT is compensated by the collocated situation, since the client can easily get information from informal face-to-face meetings with the architect. An unexpected limitation of the implementation was the need for more powerful computer processors. The object model files are heavier than the traditional line-based 3D models. With this experience, another and improved file structures could be adapted to future projects. The emerging viewer technologies could support a better overview and help preventing information overload. In this project physical views make the 3D object model easier accessible.

AHUS: USE AND IMPLEMENTATION OF ICT ON MESO-LEVEL

Although every communication between the architects and the other consultants theoretically should include the client, informal communication within the design team is usual and to some degree also wanted. All respondents emphasized the advantages of the collocated situation, with the opportunity to build up a common understanding and culture, and to exchange information and make ad hoc decisions in an uncomplicated and fast way. Because of the collocated situation, there is only a limited use of ICT and the 3D object model within the meso-level design process.

Meso-level experiences from implementation and use of ICT- some examples

As only the architects work directly with the 3D object model, the other consultants use the once a week 2D cut-offs and dwg-files as their base of planning. The cut-offs and the dwg-files are accessible in the document database. The elements received from the consultants, for instance columns and slabs from the structural engineers, the architects partly must “transform” to fit into the model. Since the architects themselves generate model objects from other consultants’ elements, they have according to respondent B, better control of the consistency between e.g. architectural and structural elements. As described, the everyday communication within the design team comprising architects and other consultants are mostly face-to-face, but also telephone and e-mail are important communication tools. Tentative and informal drawings are often exchanged using e-mail.

AHUS: USE AND IMPLEMENTATION OF ICT ON MICRO-LEVEL

Every architect working with the AHUS project shall be able to operate the ICT tools implemented in the different project parts. There are offered courses and manuals for learning and updating knowledge about continuously and rapidly developing software.

Micro-level experiences from implementation and use of ICT- some examples

The individual architect works within a 2D user environment, dragging and dropping 3D objects. According to respondent C, this way to “draw” should be easier as the traditional drawing with lines, and normally no special competence of the every day operator is necessary as long as pre-defined objects are accessible. However, till now, there are no pre-defined library of objects and building elements available. Every intelligent and IFC exportable object must be defined “from scratch”. Both defining and changing these objects means time consuming processes within narrow time limits. There are not many architects within the project having the required competence for such tasks. This leads to bottlenecks in the planning and loss of valuable time. Respondent A indicates the danger that planners could be tempted to avoid improving changes in stressed project periods. Furthermore, she points out that the lacking time and recourses to learn and be up-to-date partly lead to an inefficient use of the rapidly developing ICT tools. The implementation of the model requires that the architects working with it continuously have to extend their competence concerning the use of the software, which till now is difficult to operate, not intuitive and parametric. The narrow time limits do not allow much time for absorbing information offered through courses and user-manuals.

Respondent B emphasizes the importance of knowing the limitations and problems due to the technology used, in order to realistically understand and manage the manpower and time needed to build up the front building 3D object model. More time than expected had to be invested in programming and modelling. In the front building team, one person is full time involved with programming and building the 3D model. Also the maintenance of the room database requires extra effort, since every change must be made in both the 3D object model and this database. However, the R&D project regarding the linking of the room database with the 3D object model is partly implemented. In close future every participant in the architectural team should be able to enjoy the benefits of this combined technologies. Generally, the working with the ICT tools implemented in this project requires much discipline, effort and resources.

Both respondent A and B only to a limited degree use the 3D object model in the individual generation and visualization of design solutions. According to respondent A, she first makes some rough sketches with pen and paper, before she transforms the idea into computer generated drawings, which with its accuracy offer an early “test” of the design idea’s feasibility. However, her concern is that the middle stage between rough sketch and detailed precise drawing has disappeared, eventually leading to loss of creative freedom and overview of the totality. She tests her design ideas traditionally in 2D computer environment, using lines, not objects. Transforming the 2D lines into 3D objects is made later, which partly results in a 3D model not completely based on objects. In addition, both respondents see the lack of time recourses and the “heavy” operating of the model as the main barrier of using the 3D model directly for visualization and testing of design ideas. However, respondent A emphasized the possibilities of reusing details and solutions as a benefit of ICT and a support of generating design solutions.

SUMMARY

The ICT impact matrix (Table1), which is based on the three hierarchical levels and the selected four design process aspects, summarizes some of the experiences made due to the use and implementation of ICT in the AHUS project. The focus of the 3D object model in this project lies more on the implementation of an object-oriented way to work than the possibilities due to 3D visualization (Bakkmoen, BuildingSMART conference in

Oslo, 31.05.-01.06.2005). According to the interview respondents, the key advantages and possibilities of the ICT are better project material quality and consistency, and a more uncomplicated project transition from planning to construction. However, much time, competence and effort are invested in modelling and programming, partly caused by the lack of pre-defined objects. The model is “heavy” and difficult to use regarding the normal design process day. But all respondents, also the every-day users of the 3D object model, are aware of what they perceive as the overall benefits of using the ICT tools in this project, such as better control of rooms and equipment, the generation of building descriptions, the quantity take-off etc. Especially when it comes to the construction of the building, the key persons behind the ICT implementation hopes to “reap the fruits” of the many participants’ effort and commitment.

CONCLUSIONS

This paper has illustrated how the introduced three-level-approach can be used to explore the ICT impact on a hospital development project in Norway. The tentative impressions of the approach’ adaptability on practice, is the potential for supporting and guiding the collecting, analyzing and presenting of the empirical data. Regarding the project presented in this paper, the approach helped keeping overview of actors and processes, and their experiences due to use and implementation of ICT. There are of course still several aspects to be further developed and clarified, especially regarding the definition of the levels and the understanding of the interactions between them and the four design aspects. The intention behind this approach is not to force aspects of the complex architectural design process into rigid categories, rather it aims to contribute to a better overview of how ICT impact on the building design process in general, and on the architect’s role and contribution within architectural design and management in special. This paper only presents the first impressions of the approach’s adaptability on practice. For extending the empirical basis, further case studies and interviews should be carried out. Also more participants of the AHUS project could be interviewed, not only architects. The applying of the approach to more real-life projects could on the one hand contribute to further improvement and development of the approach, and on the other hand contribute to a better understanding of how ICT impact on the design process and the architect’s role and work.

ACKNOWLEDGEMENTS

This paper is a part of a PhD study and doctoral scholarship financed by the Norwegian University of Science and Technology (NTNU). The writing of this paper would have been cumbersome without the support and good advice from professor Tore Haugen (main supervisor of the PhD-project), who suggested the AHUS as case, and associate professor Birgit Sudbø. A thank goes also to Kjell Ivar Bakkmoen, Bård Rane, Astrid Seeberg and Steen Sunesen for their willingness to sacrifice time and effort, giving interesting answers on many questions.

Table 1: the ICT impact matrix, outline summary of experiences from implementation and use of the 3D object model

	Micro-level	Meso-level	Macro-level
Generation of the design solution	**Use and experiences:** • 3D object model not used directly for design generation, rough hand sketches and 2D line-based drawings the facilitators of design generation – after finding an appropriate solution, it is "transformed" into object-based modelling. • 3D object model heavy to operate and change – it is not intuitive and parametric. • Individual architect is working within a 2D environment, dragging and dropping 3D objects. • No pre-defined objects available, every object and element must be defined from scratch – time consuming. • Few people have competence to change objects – bottlenecks and delays by changing - danger of avoiding improving changes. • Possibility of reusing solutions and details benefit.	**Use and experiences:** • Ad hoc solutions mostly developed using traditional tools as pen and paper, physical models etc. in a face-to-face environment.	**Use and experiences:** • Rigidity of ICT generated finished looking drawings and illustrations presented in the meetings paralyzed the participants and made it difficult for them to suggest changes. In this case, the ICT tools did not support dynamic, open and flexible discussions.
Communication within the design process	**Use and experiences:** • 3D object model not used directly for design generation, rough hand sketches and 2D line-based drawings are the basis for the "designers conversation with the design situation" (Schön 1991)	**Use and experiences:** • On this level there is mostly informal face-2-face communication. • Only architect work with 3D object model. • Once a week cut-offs from model (dwg) is made accessible on document data base. • Exchange of tentative data by using e-mail.	**Use and experiences:** • All participants have access to document and room database – always up to date material. • Use of beamer makes the project material easy accessible to all participants in meeting situations. • 3D model itself a "black-box" for client, unless special competence. A limitation of directly following the design development. In this project collocated situation compensate the limitation.
Evaluation of the design solution	**Use and experiences:** • Much information to be overviewed and maintained in the model, development of viewer technologies could help focusing attention for evaluation. • Use of hand-drawn perspectives, sketches and 2D computer line-based drawings rather than directly using 3D model for evaluation– which is to "heavy", unless special competence.	**Use and experiences:** • Today, the 3D object model is only to a limited or no degree used in design idea evaluation. • However, the model shall in close future support simulations of e.g. indoor climate etc. • The architect partly "transforms" slabs and columns from structural engineer to 3D model objects – gives opportunity to directly control consistency between architecture and structure.	**Use and experiences:** • 2D views and cut-offs of the 3D object model regularly accessible to the client and the other participants. • The 3D object model not directly used for "live" simulations and visualisations in meeting situations – model to "heavy" and the IFC version implemented does not support rendering of the objects.
Decision-making within the design process	**Use and experiences:** • Use of hand-drawn perspectives, sketches and 2D computer line-based drawings rather than directly using 3D model for decision-making. • The model-checker enables clash-and doubles detection of 3D object model –higher quality and consistency of drawings before passing drawing to next level.	**Use and experiences:** • On this level there is mostly informal, ad-hoc and face-2-face decision-making. Formal decisions on macro-level. • Ad hoc decisions based on f2f discussions and the use of pen, sketch paper and physical drawings.	**Use and experiences:** • Decisions made only in formal meetings. • In the project meetings participants have own laptops – always directly access to data base and up to date material. • High quality and consistency of project material. • Generation of drawings from 3D object model benefit when decision material regarding 1000 unique room must be made.

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CHANGE MANAGEMENT FOR USING A PROJECT WEBSITE IN DESIGN TEAM COMMUNICATION

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Abstract
A Project Website (PWS) has been advocated as an important tool for design teams of construction projects, because the tool is supposed to greatly enhance team communication. This, finally, should result in improved team performance in terms of increase of efficiency and effectiveness. PWS vendors claim these results on expected better communication of teams who share and update their design information using a PWS together. The growing use of IT tools by design team members who electronically generate, collect and update design information increases the need for such an IT tool that allow fast and easy access and overview of the status of the latest changed and generated design information of the whole team. Also due to the growing complexity of building projects, the number of design partners and the number of electronic means for communication, the need for better collective communication is more important then it has ever been before. However, due to the expanding complexity and changes in design information, the redundancy of design information is growing too and the risk to failures. Team members need new skills for collective use of a PWS. The use of the tool might need radical changes in information flows to become effective. It might be experienced also that use of a PWS formalizes team communication too much, or might be threatening because of 'big brother effects'. Within this view the change to collective use of a PWS by a design team is not an automatic change to an effective communication environment as vendors like us to believe and many pitfalls can be encountered. In this paper the most important aspects of change to collective use of a project website for team communication will be discussed, based on the results of a Dutch PhD research project.

Keywords: Change promoters, project website, rivalry of tools, second-order change, technological frames.

COMMUNICATION ASPECTS
To communicate collectively it is important that all members of a group are involved actively in the group's communication. According to Ruler (1996) three concepts of communication can be identified: inter-active, effective and active. These communication concepts are mainly based on differences in communication processes regarding feedback (expected by the sender) of a receiver or group receivers. Feedback is a type of message that the receiver transmits to the sender in response to having received a message (Wiener, 1948). Shannon and Weaver's communication theory (1949) is the basis for this approach. Ruler's interactive concept is defined as a back and forth process between sender and receiver(s) with changing roles. In this process, feedback is essential for communication (for example: in a dialogue, telephone conversation or group meetings).

	Same time	Different time
Same place	Dialogues Informal meetings Formal team meetings	File management Bulletin board Paper project dossier
Different place	Telephone Tele conferencing Video conferencing Instant messaging	Postal + interoffice mail Facsimile Computer network Email MS-outlook calendar

(Matrix adopted from Baya, 1995, Milad, 2001)

Figure 1: Time/space matrixes of commonly available communication means for design teams

The effective concept is defined as a one-way process with an active sender and passive receiver(s) with a predictable re-action. In this process, feedback is possible but not expected (for example: postal mail, facsimile). The active concept is defined as an active one-way process of a sender, for broadcasting or publishing of information to receivers. In this process, the same channel of communication usually cannot give feedback (for example: the Queen's Christmas message on television). A sender might use a specific communication means to send a message to receiver(s) depending on the sender's need for feedback, the available means and his preference for use of a specific means synchronous or asynchronous. Synchronous communication can be defined as the communication between senders and receivers at the same time, whether or not it is in the same place (Robbins, 2001) while asynchronous communication between senders and receivers takes place at different times and mostly at different places. Figure 1 gives an overview of commonly available means for synchronous and asynchronous communication, structured by their time and place relation.

COMMUNICATION IN ARCHITECTURAL DESIGN TEAMS

Architectural design teams can been defined as temporary, multi-disciplinary and network based organizations of collaborating specialist designers. Design team members usually are designers with a management task and can be characterized as creative, visionary, spatially aware and abstract thinking practitioners with a high level of technical knowledge and experience (Schön, 1987). In today's architectural design teams, a growing number of specialist designers are required to execute equivocal and uncertain tasks in accomplishing the necessary performance of the design (Loon, 1998). The key information carriers of designers mostly are sketches, schemes, images, drawings and written descriptions together with explanatory stories. Knowledge about the design exists on a cognitive level of team members, on the level of collaborating design team partners and on the design team's external level via the client, users and other stakeholders. Team members generate new knowledge by collecting, sharing and transforming information about the design to be produced. Communication is necessary to facilitate these processes. To distribute generated design knowledge among team members for the progress of design they communicate both synchronously and asynchronously using the available means of communication (e.g., Davenport, 1997; Donker, 1999).

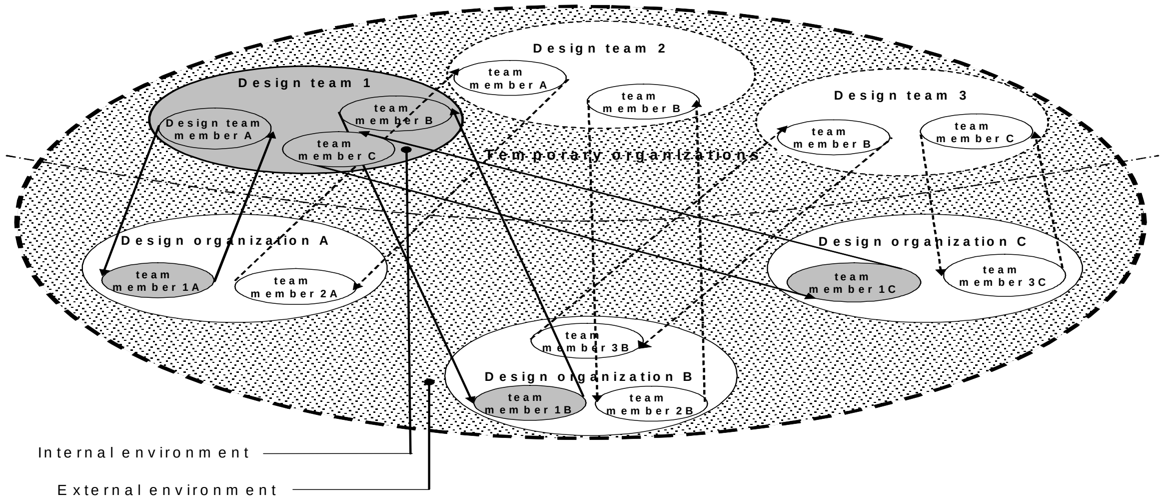

Figure 2: The information environment of design teams

They need to process their own specialist data before useful information can be delivered to others. Not all designers participate in the same way at the same time. There are many who participate as individuals, working alone for crucial periods and then returning to the network process (Latour, 1987). Moreover, design team members greatly depend on the most current design information to work out their own design tasks (Kvan, 1997; Wiegeraad, 1999). Specifically in design teams that are organized for integral design, asynchronous communication is of great importance because of the designer's dependency on each other's generated and updated design information. Thus team communication of an architectural design team might be defined as the compilation of all processes for sending and receiving messages between team members individually and collectively using the various, available means of communication (Sproull, 1991). The design to be made is mainly both visualized and discussed by team members. For this reason, the design process of architectural design can usually be characterized as a continuous process of change that has to be well documented and updated because typically many stakeholders are involved. In the team's external environment, communication with their client, users and other stakeholders takes place. In Table 1 an overview is shown of attributes of the available means of communication and a PWS. The specific attributes of a PWS concerning overview, status and version, are marked.

Means of communication	Fast	Ease of use	Feed-back	Struc-tured	Over-view	Infor-mal	Formal	Contract docs	Info owner	Info updater	Status	Ver-sion
Postal mail	-	-	-	-	-	-	xx	xx	x	-	xx	-
Facsimile	-	x	x	-	-	-	xx	x	xx	-	xx	-
Project dossier	-	-	-	x	-	-	xx	xx	x	-	-	-
Email message	xx	xx	xx	-	-	xx	xx	-	xx	xx	-	-
Email attachment	xx	x	-	-	-	xx	xx	-	x	-	-	-
Outlook calendar	xx	x	x	xx	-	-	xx	-	xx	xx	-	-
Computer network	xx	xx	-	x	-	-	x	-	-	-	-	-
Project Website	xx	x	-	xx	xx	-	xx	x	xx	xx	xx	x

Table 1: Overview of attributes of means of a-synchronous communication

Interactive mode	Effective mode	Active mode	Re-use mode
Use of PWS In workflow of integral design, in every days work with a high frequency of generating and change of information	Use of PWS in workflow, in every days work or in integral design processes	Use of PWS for sharing of information between design partners, for publication of information to client and stakeholders.	Use of PWS as information archive with final information for re-use of design information in other design projects
Storage and updating per hour or less	Storage and updating per day or per 1/2 day	Storage and updating when files are printed for publication to client / stakeholders	Storage of information when the design phase is finished

Figure 3: PWS modes of communication

Based on Ruler's concepts of communication the use of PWS might be classified to four different communication modes (Figure 3). The inter-active mode of communication is defined if files are stored, updated and read in less than four hours or half a day; the effective mode of communication is defined for storage, updating and readings once per day; the active communication mode is defined when storage and updating are less than daily and might be related for instance to team meetings or printing activities for sending information by postal mail; the re-use communication mode is defined as the digital library in which all finalized files of a project are stored. A substantial contribution of PWS-use for team communication might not be expected in active and re-use mode because of the low frequency of updating. Feedback of readers of PWS-information is expected to increase more if a PWS is used in effective and inter-active mode because of the higher frequency of generating and updating.

RESEARCH FINDINGS

In this section the results of a Dutch research project (Otter, 2005) are discussed concerning design team communication and performance using a PWS. The adoption and use of a PWS was investigated first, by means of a multiple case studies in a large design organization, regionally organized in units in which design teams used a PWS. By comparing the team communication of two teams in each unit that executed comparable projects in size and complexity, differences in PWS-use were extracted. One of the teams, the experimental one received extensive training for use of the package while the control team only got user instructions and a manual for PWS-use. Team communication concerns flows of information between members of a group through specific channels by using the available means of communication. Team communication is not restricted to transfer of information, but concerns all activities of information handling needed for the exchange and storing of information through specific channels to members of a group, individually and collectively. Discrimination between synchronous and asynchronous communication is necessary because of substantial differences in synchronous information flows using voice, ears and brains for generating, transmitting and storing information compared to asynchronous flows by a) paper using postal mail channels and paper dossiers for storage and b) electronically using electronic means for storage. According to our conceptual framework, the mixed use of these means of communication is required to improve team communication.

	Design firms	Design & construction firms
Communication mode	Active mode	Effective mode
Change management	First-order	Second-order
Management approach	Top-down	Bottom-up
Re-design of workflow	No	Yes
Re-design of information flow	No	Yes
Rivalry between PWS and computer network	Yes	Yes
Change agents	No / Re-active	Pro-active
Change implementers	No	Yes
User training	User instructions	Team training
User platform	Some	Yes

Table 2: Overview of findings of change management aspects for effective PWS-use

Team communication was investigated by measuring the frequency of using available different means of communication and the information handling activities for collecting, storing, reading, and maintaining information. Moreover, team communication and preferences for using specific means of communication were identified by asking questions about use, information handling and preferences for using particular means of communication. Finally, effectiveness of the use of a PWS for team communication was operationalized by measuring changes in the frequency of using means of communication, caused by PWS-use as a new means for team communication. The results of the multiple research project show that the PWS was not used collectively in the effective communication mode and rivalry between PWS-use and parts of the computer network was detected while now effects on team communication and small effects on team performance were observed. The outcomes also suggest that team training and a bottom-up management approach actively involving users in the change, better stimulate PW-adoption. However, if a user platform is organized for this purpose, and not managed by change agents, the focus on the change might move to the re-use mode instead of the effective communication mode. The PWS was implemented as a first-order instead of a second-order change (Levy, 1986) mostly by using a top-down approach of management. Ideally management style should show a bottom-up approach using pro-active change agents and stimulating more interaction with ultimate users.

Second, to derive more general findings, the outcomes of the multiple case studies were reflected to the experiences of a substantial number of design firms and design & construction firms, using the same and different PWS packages that were chosen by the vendors of PWS-packages. The results of these so-called mini-cases show that most design & construction firms use a PWS collectively in the effective mode of communication successfully that affects team performance (Table 2). The design firms use a PWS in the active mode of communication not showing substantial changes in team communication or performance. Rivalry between PWS-use and use of parts of network disks was reported in almost all firms, which might prove it to be an important cause for the non-adoption of PW-use. Design & construction firms appear to have better results with the adoption of a PWS, by planning the change as a second-order change, redesigning workflow processes to optimize PWS-use and avoiding rivalry of tools, testing PWS-users on their PWS-competences, pro-actively using change agents, and reporting a bottom-up approach by organizing user meetings to stimulate PWS-use.

PLANNED CHANGE

Concerning the planning of change using a PWS in team communication, Levy argued that discrimination between a so-called first-order and second-order change is important to identify the nature of the change. First-order changes concern changes that do not change the system's core. "First-order changes are linear and continuous. It implies no fundamental shifts in the assumptions that organizational members hold about the world or how the organization can improve it's functioning". Robbins (2002) argued. "Second-order change in contrast, is a multidimensional, multilevel, discontinuous, radical change involving reframing of assumptions about the organization and the world in which it operates". Clear goals, tasks and responsibilities need to be defined for change agents, in particular for the change implementer (Kanter, 1992) on workflow level to stimulate the collective PW-adoption by design team members. By using a bottom-up approach, using change implementers and involving users in the change, management need to involve non-adopters and laggards, which more specifically were identified in the multiple case studies as the architects and structural engineers. These designers showed to be less involved in the change compared to the other designers. In addition, where possible, change should be managed from a pull as opposed to a push setting. Rivalry between IT-tools combined with insufficient user insight into the use of the tool in their daily work and insufficient changes in workflow leave opportunities open for the development of incongruent technological frames between individuals and groups. Orlikowski (1994) states, "Where the technological frames of key groups in the organizations, such as managers, technologists, and users are significantly different, difficulties and conflict around the development, use, and change of technology may result". She uses the term technological frame to identify the assumptions, expectations and knowledge that members use to understand technology. This includes not only the nature and role of technology itself, but also the specific conditions, applications and consequences of that technology in particular contexts. To analyze and discuss whether such technological frames between groups in an organization are incongruent, she distinguished three aspects: nature of technology, technology strategy and technology in use.

MANAGED CHANGE

With respect to the management of the change process, Lewin (1951) states that change agents are needed to 'unfreeze' the organization. Similarly, Tichy (1986) argues that the organization needs to awake by mobilizing driving forces of change, promoting the benefits of change, trainings to get the required user skills and the benefits in daily work (Kanter, 1992), removing restraining forces to change and making the change operational in the organization. Because of the need of collective use in the same way, team training in using the PWS collectively on a daily base is necessary to show possibilities and how sharing of information is expected, what is expected of use of the system and how all team members have to change their existing information processes and working habits, needed to achieve the defined targets. In the multiple cases studies, the organizing of PWS-team workshops showed to be important to increase PWS-adoption and use. In the most successful design & construction firms using a PWS, prescribed use was tested and certificates were presented to successful users. It is also important to choose which tactics to use for change management: fast or slow change, changing a part of the organization or the organization in total, and focusing on change by individuals or by groups (Lawler, 1989). After execution of the change, ‘refreezing’ the organization is necessary to establish the new routines as part of the organizational routines.

To remove restraining forces to change and making the change to effective PWS use operational in the organization, a change leader is needed. Hauschild and Kirchmann (1998) did research to drivers for technological change in organizations that changed successfully, and introduced the Troika of innovation (Figure 4), in which the process promoter was introduced besides the power promotor and the technology promotor and the need for interaction between these promoters. The process promotor, they stated, is the champion of the innovation and is needed because the power and technology promotor are not able in their positions to discuss changes on the workflow level.

The Power promoter is needed for formulating the goals underlying the innovation, in this case the effective use of a PWS: what performance improvement is desired/expected by using a PWS and how can this be achieved? In terms of management of conflicts, this person needs to manage conflicts resulting from incompatible demands for resources and from incompatible power of positions. *The Process promoter* is needed for project- and interface management tasks regarding the innovation, networking, providing information about human and financial resources. His or hers main task is to solve and/or dismiss resistances in the team and between the team and the organization against the innovation. This person is ‘the man at the helm of the innovation’. The process promoter manages change effectively by knowing the organization very well and connecting persons who are pro innovation (driving forces) as well as debates and negotiates with persons who have antagonistic motives (restraining forces). He indicates conflicts on the organizational-, department-, or personal level. The Process promoter tries to solve these conflicts himself or involves the power promoter to solve these. The promoter by organizational know-how and the champion of the innovation, which in case of a PWS might be identified as the transformational leader of PW-use (Tichy, 1986). *The Technology promoter* is the expert of the IT possibilities, databases, integration of systems and technological problems involved. This person, the IT system manager of an organization knows all about the use of PW and the best way to use PWS effectively. This person assesses existing solutions and generates new alternatives if problems occur to use the PWS for specific tasks. The technology promoter is necessary in the management of conflicts due to contradictory perceptions and information. Kirchmann (1994) showed some evidence that a Troika structure achieves better economic results than any other structure.

Lechler (1997) was able to confirm the assumption that the probability of the occurrence of a process promoter and his positive influence on a project’s outcome increases with problem complexity. The process promoter should be well known in the organization on workflow as well as on management level, not being a team member because of the hierarchical position to the team leader. Both in the multiple case studies and in the mini-cases evidence for the functioning of the Troika was found. The organizing of a user platform at the start of PWS-use shows to be important in a bottom-up approach getting users involved in the change and giving change agents and implementers the chance to discuss user problems that occur related to technical issues, adoption and daily use.

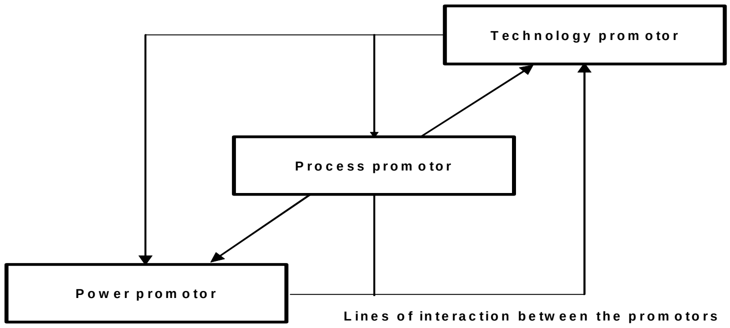

Figure 4: Troika of Promoters for successful innovation

BUSINESS PROCESS RE-DESIGN

The design & construction firms that changed successfully using a PWS collectively in the effective communication mode showed re-design of workflow and information processes to optimize the use. In the multiple case studies, only some information flows were changed during the change. However, by leaving the old manual processes open for use it was ambiguous for teams to change trusted work habits. Hammer (1993) argues that re-designing means much more reshaping of processes by differently organizing the work done. In planning second-order change, the radical re-design of existing information processes to effectively and efficiently use new tools should be a part of it. Re-designing should concern both the re-design of manual processes concerning tasks and responsibilities, and re-design of communication flows. By defining and implementing the new processes as part of second order planned change and by indicating how and for which purposes to use these efficiently, designers (specifically architects and framework designers) may easier discover the advantages of collective PW-use in their daily work. This may also help avoiding the development of incongruent technological frames. PWS by nature is a push system compared to Outlook Email because it has to be filled first by its users before it becomes of value for users.

CONCLUSIONS

If the results of the mini cases can be generalized to similar organizations, they suggest that the following conditions are probably to improve the acceptance of the new technology in general and PWS's in particular: (i) rivalry of tools should be avoided from the start; (ii) a team should have sufficient skills to use the technology as good as the rival tools; (iii) both workflow and information handling processes should be redesigned for efficient and effective PWS-use; and (iv) pro-active change and implementing agents are made responsible for the successful change of PWS-use to a pull-setting for users. The IT Productivity Paradox was also observed in design teams in architecture, construction and engineering using a PWS. It differs however in intensity as a function of how change management is implemented. Successful adoption and implementation of PWS and technology in general requires management of a second-order change process. In any case, the ultimate adoption and impact of new technology depends on the extent to which it is perceived as beneficial to design team members in integral design processes on a daily basis. In that sense it may be a more fundamental limit to the impact in professional architectural design teams. Because of the limited number of design teams observed in the research project only the starting of an answer can be given. Replication research is needed to provide full answers for improvement of collective communication in architectural design teams using a PWS.

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SMALL GROUP INTERACTION RESEARCH METHODS

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Abstract
Growing interest in construction communication is not matched by scientific research. Observing, capturing and understanding the behaviour, dynamics and nature of even a small group's interaction is difficult to do in practice. The speed of interaction and the various sociological, psychological and environmental factors that colour communication complicates the process. If scientific research is to be undertaken in this area the tools used to capture and analyse group interaction must be relatively simple to use, repeatable, robust and effective. A problem faced by researchers in this area is whether available research tools are appropriate and capable of capturing meaningful data. A small study was designed to review five communication research methods and tests their usefulness on a group of post-graduate research students studying group interaction in construction. The practical limitations associated with each method are discussed along with their potential benefits. The results show that careful consideration needs to be given to the use of research tools. Even the most basic research methods and data sets, such as transcripts, can be compromised, if researchers do not adopt a valid and consistent approach.

Keywords: Communication, Construction, Research methods, Small group research.

OBSERVING GROUP INTERACTION

Selecting an appropriate research method is fundamental to the development and completion of a good piece of research work. To ensure that the research process is effective researchers must quickly come to terms with the strengths and limitations of research tools and identify suitable methods for the context. Methods used must extract data that is capable of answering the research question. In their evaluation of different research methodologies Seymour and Hill (1993:121) claim that the most important question a researcher can ask is 'what is going on here?' This is particularly true of communication and group research that focuses on the interaction characteristics of people. The physical size of construction projects, the length of time from inception to completion and the intricate social networks that develop during construction projects prove a formidable challenge to researchers. It would seem an impossible task to understand the whole of the construction sector and its projects, but greater insight can be gained from studying key parts of the process. The research reported here aims to investigate the usefulness of a number of research tools and expose their strengths and limitations. While it is fully envisaged that such tools would be used to collect data from group interaction within the construction context, this study collected the data from student groups in a relatively controlled environment. A number of doctoral studies were also reviewed to gain an insight into problems experienced when methods are used to observe 'real' bona fide groups in their natural context.

Observations of bona fide groups

Due to the sensitivity of the business environment it is usual to negotiate the degree of observation and the method of recording interaction before the researcher is allowed to record data (Hugill 1999; Abadi 2005). Not understanding or fully knowing what the research will achieve, who will see the research data, or what it will be used for can be perceived as a major concern to those being observed, keen to limit intrusion and maintain privacy. There are limited incentives for agreeing to take part in research and many reasons can be found for not participating. Research may interfere with the natural flow of business, those participating may behave differently and the research will consume some of the participants 'own' time, thus there may be little reason to get involved. In some situations it may be difficult to gain access to 'real' construction environments. However, studies that have collected data on group behaviour in their natural 'construction' environment, suggest that, once underway, access is allowed to most situations (Wallace 1987; Loosemore 1998; Hugill 1999; Gorse 2002; Abadi 2005). The method chosen should be suited to the research purpose, while not compromising the interests of the participants. This means that some degree of compromise on method may be needed. For example, video and audio recordings provide rich sources of data, but participants are often reluctant to let such equipment be used, although less resistance may be experienced with written records (Gorse 2002). A less desirable method may reduce the richness of the data collected, but may be difficult to avoid if there is no other practical way of collecting data from a specific situation or event.

Classification Communication Acts and events

Most communication research is based on observations of external factors, such as the sending and receiving of verbal and written messages, facial expressions, emotions and body language, or reactions to these messages. Rather than collecting intricate data, which may differentiate between every word uttered or attempting to capture all of the nuances of interaction, behaviour may be summarised and collected under a classification system. Observation of overt factors of communication, identifying who makes the communication act and whom it is specifically directed at, has been termed the 'surface meaning' of communication (Heinicke and Bales 1953; Emmitt & Gorse 2003). Surface meaning limits observations to those communication acts that are most obvious to the observer and participants, i.e. to acts that are instantly recognisable. Researchers cannot observe abstract concepts; therefore, aspects of interaction should be translated into observable phenomena, using operational definitions for each of the conceptual variables (Clark 1991). It is important to establish low-level constructs, simple definitions of observable phenomenon, which can be explicitly tied to the data, before communications at more abstract and possibly more complicated level can be developed. Simple observations provide robust data; complex systems tend to be less consistent and reliable. Poole *et al.* (1999, p.106) notes that, 'the design of coding schemes involves a complex set of choices, and these choices determine what claims the resulting data can support'. The findings of a coding system are tied to the method used to capture the data. There are limitations involved with the results and difficulties when attempting to compare results that have been obtained from different systems. The Bales (1950) interaction process analysis (IPA) is one of the most widely used techniques to study overt group interaction. Doctoral research by Gameson (1992) and Gorse (2002) both used the IPA method in its original form to study construction professionals. Wallace's (1987) study of design team interaction used a bespoke system that contained some elements of Bales' IPA and parts of other methods: which made it very difficult to compare the data with research that applied Bales IPA without modification.

Video and audio recordings

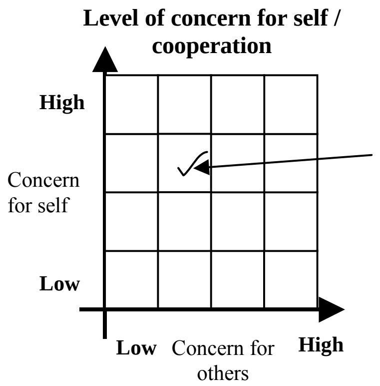
Participants often give permission to audio record 'one-to-one' interviews and the use of audio recording is a common method of collecting data. Taking notes is often avoided as it may interfere with the flow of the interview. Gameson's (1992) study of interaction characteristics associated with construction professionals was based on data collected from audio tape recordings of interviews. However, using audio and video recorders to record 'real' professional interaction as it occurs may meet with resistance. Hugill (1999) used audiotape to collect interaction data from site meetings, and made a point of noting the difficulties of gaining access to this sensitive business environment. Even when allowed to observe meetings it was some time before permission was granted to audio-record the meeting's interaction, and, occasionally, the researcher was asked to turn off the recorder.

Retrospective accounts and reflections

Self-reports (or measure) of the subject's feelings or beliefs can be used to produce retrospective accounts and reconstructions of actions and events. This type of methodology assumes that people can provide relatively accurate accounts of past events. While such accounts may be abbreviated and distorted, they provide a source of data that are otherwise almost unobtainable (Clark 1991). Diaries have been used in construction to gain reflections and accounts of events. Some thought should be given to who makes and records the reflections and the period between the event and recording of the account of the event. Emmitt's (1997) diary was completed by the researcher who consistently recorded events immediately following the observation, whereas, Loosemore (1998) diaries were completed by the subjects. Unless controlled, periods between the event and participants recording of the event will vary, as will the accounts, and hence the reliability of the data. Collecting information after the event can help to reduce the problems caused by a researcher observing sensitive negotiations. Although Loosemore experienced problems with the use of diaries during sensitive periods, there were few problems when collecting information after the event. However, Loosemore found that where events had caused emotional impact, people remained emotional about their experience and this prevented them giving a true perspective of occurrences. People tend to remember and recount periods of heightened emotion rather than recall all of the more mundane detail of events (Gorse 2002).

Multiple Level Observation

Multiple level observation systems are useful for reducing some of the limitations associated with individual perceptions. Rather than limiting observations to an independent researcher, such systems use participants to observe others and reflect on their own feelings. Those engaged in the discussion are asked to consider the actions of themselves and others in relation to a specific situation that involves a group experience. In small groups each individual provides data on their own behaviour and every other members' behaviour. To add a third dimension, independent observers also provide data. The advantage of participant study is that observations are not just limited to overt interaction and behaviour, but they also capture the participants' own feelings and values of their self and others within the group. Simple Multiple level Observation Techniques (SMOT), such as that suggested by Fryer *et al.* (2004), allow researchers and participants to pick a specific issue, event or period within the group context and use multiple perceptions to investigate it. The individual and group perceptions can be explored in some depth. There are standard multiple level observation systems, which have the benefit of being consistent in whatever context the research is set. Behaviour management profiles, a development of Blake and Mouton's (1964) two-dimensional grid, can be used to quickly establish self-perceptions and perceptions of others on a particular issue of group behaviour (Figure 1). While helping to collect data from multiple perspectives, the grids are more of a discussion tool, helping members to focus their attention on different issues and comparing their thoughts with others. Some multiple level observations methods are complex (Poole 1999). For example, Bales and Cohen's (1979) SYMLOG (System for the Multiple Level Observation of Groups) takes three to four hours for a group of five to complete the forms (Bales 1980); for this reason alone, the use of Bales' SYMLOG is often impracticable.



The grid is used to rate each member's behaviour within the group situation. Each member completes a grid that represents their own behaviour and then completes further grids to indicate their perception of how other members behaved.

A tick is placed in the box that most closely reflects the perceived behaviour.

Figure 1. Behaviour management profile (From Fryer *et al*. 2004)

RESEARCH METHOD

The usefulness of a number of research methods used by researchers undertaking small group research for the first time was tested. Eighteen postgraduate students were given the task of observing and analysing group behaviour using different data collection and analysis methods. All students took part in one of three 30-minute group discussions, each discussion was recorded on videotape. Following the meetings a video recording was distributed to each of the participants. The students were then asked to transcribe the data, quantify communication acts and code the communication using the Bales (1950) IPA method. Students were asked to use the video and audio data to extract qualitative observations. They were also asked to use two further tools to explore perceptions of the group experience, these included Fryer *et al.'s* (2004) Simple Multiple Level observation Technique (SMOT) and behaviour management profiles. A period of 4 weeks was allowed for the students to learn how to use the techniques and to explore and analyse the data produced. Following this exercise the students were asked to reflect on the tools' strengths and weaknesses.

RESULTS

The following results are based on the reflections provided by the students. Some of the students' comments were identical, and where this happened only one entry is made in the results. The responses have not been ranked or ordered in any way. A summary of the responses made in relation to each of the research tools is provided below followed by a brief discussion of the results.

VIDEO DATA AND OBSERVATIONS / REFLECTION OF VIDEO DATA	
Strengths	**Weaknesses**
Events and situations can be observed and reflected on.	Can be difficult to interpret any underlying intentions, may be considered wrong to infer intentions. Other methods should be used to identify the participants' intentions during a specific sequence of event. Participants could be asked to review the video and asked what their intentions, thoughts, beliefs etc. were during the specific episode of events.
Provides initial understanding of the group interaction, good base to work from.	While the data is rich and real, it is still difficult to capture every communication act, participants talk over each other and interrupt.
Accurate account of discussion.	Some utterances and statements may not make sense.
Data set in context, some surrounding information available.	Video observation is time consuming.
Can judge positive and negative reaction, often missed in other data.	While emotion and body language can be observed, it can be very difficult to transfer non-verbal observations into the written form.
Body language, voice tone, intonation and emotion can be examined. Emotional context can change literal meanings of words considerably, which is missed in transcripts.	Relying on video data without proper analysis can be too simplistic and subjective, lacks systematic rigor, no way of judging whether a group is typical or not.
Disjointed conversations make much more sense and gain a congruent reaction. Transcripts of such event are meaningless.	Subjects are aware of the camera and their behaviour may be affected.
Recordings are essential to recall what happened.	How does an observer record what is going on when it may not be clear to the group?
Without video data other analysis can be inaccurate.	Camera positions mean that behaviour is missed, multiple cameras may be required.
Useful for cross-examining perceptions, whether individuals do what they say do.	Individuals may hide their interaction from the camera.
Participant, non-participant and external observation can be used to assess data.	
Can be watched by many different people – obtaining multiple observations. Can be used for many different purposes.	
Requires little training, however, quality of observations dependent on researcher's training, experience and skill.	
Can be repeatedly reviewed to capture the subtle nuances of interaction.	
Recollections of events, based on memory alone, are sometime different from the video evidence.	
Issues can be examined in detail, look at what created these scenarios and how the group collectively and, or, the individual reacted.	
Allows relationships, dominance, blocking, conflict, leadership, seating arrangements etc. to be assessed.	

Facilitates the use of other analytical methods.	
Can be played at different speeds, this often identifies behaviours not apparent at normal speed. In the fast forward mode it is easy to notice the members who remain motionless and others who fidget or move.	

QUANTIFYING COMMUNICATION ACTS, IDENTIFYING THE ACT, THE SENDER AND THE RECEIVER

Strengths	Limitations
Simple, accurate and relatively consistent statistics produced across different observers. Although quantities produced by the observers can vary, sample sizes are so large that the differences are not significant.	Recording communication acts is laborious and time consuming
Reveals trends that are not apparent without it.	Sometimes it is difficult to know who is speaking to whom.
Useful for identifying pairs who work together and subgroups.	Sometime difficult to identify an individual recipient, so it is taken that the whole group is being addressed, rather than a particular individual.
Provides indication of the participant's willingness to be involved.	Can be more than one intended receiver, but not broadly directed at the group.
Allows the researcher to look at individual and group level communication and examine who sends the data and whom it is sent to.	Impossible to capture all communication acts.
The group can be split into sub-groups e.g. male and female and interaction examined within these categories.	If the group divides into subgroups and separate conversations take place, it is difficult or impossible to identify all communication acts.
Allows patterns to be identified, e.g. who contributed throughout, who interjected periodically, who appeared to dominate the proceedings and which members were reluctant to communicate.	Frequency counts do not indicate the nature, quality, relevance or length of communication.
Quantitative data can be examined over time (longitudinally), during different phases or time periods (segmental) or as one unit of data for a group, or individual (cumulatively).	Does not show periods when no interaction takes place. However can be presented over time rather than cumulative to show who talks when and when nobody talks.
	Does not recognize less frequent communicators that nonetheless make a valid and possibly lengthy contribution.
	Fails to identify or discount verbal messages that are sent, but not received.

CODING AND CATEGORIZATION OF COMMUNICATION ACTS, E.G. BALES IPA

Strengths	Limitations
The group as well as the individual discussion can be broken down into different categories, which are easily analysed, in many different ways, once the data is collected	Some interactions are difficult to classify, especially for the untrained researcher.
Standardization: some methods, such as IPA, are widely	Where understanding of a communication category starts out incorrect, they will probably continue to be incorrect.

recognized and can be compared to other research.	One act may seem to fall into two classifications and a decision needs to be made.
Can be used alongside other methods for cross comparisons, e.g. Belbin's team role classifications.	Without training to calibrate observations, the results may be inconsistent and unreliable.
Codification correlates between different observers.	Contributions from group members with different international origins can be difficult to classify, especially if their English is not always correct. Interpretation may be incorrect.
Easy to categorise acts, after some practice.	Observer may have social and cultural expectations that mean that they can never be entirely objective.
Methods, such as Bales IPA, that have survived from 1950s this suggest they are powerful data collection methods.	No way of recording whether the message was received and understood.
Can just concentrate on one, two or all of the categories.	The method is very useful, but has little relevance unless it is combined with other methods. Other methods help to explain what happens during occurrences and trends.
The classification helped to identify points in the group discussion that could be investigated further using other techniques.	Neglects the comments of what was said.
Useful for identifying categories, e.g. questions and then, cross-referring to other data, e.g. video or transcripts, to look at whether participants openly gave information or whether it was coaxed out.	Many comments have numerous purposes and meaning, classification relies heavily on the observers ability to judge and categorise.
Can check who dominates under different categories – can be quite different to who is most talkative.	Can be misleading when not fully understood.
Helps to understanding group dynamics.	If the meaning of the speaker is misunderstood the classification is incorrect.
	Takes time to develop natural understanding, the Bales IPA system recommends three months training.
	Where relationships between observers and researchers exist, there may be bias when analysing the data.
	Concentration levels can be difficult to maintain over long coding periods.
	Does not capture or categorise for every situation.

BEHAVIOUR MANAGEMENT PROFILES (CONFLICT MANAGEMENT PROFILES)

Strengths	Limitations
Allows a participant to consider a number of issues.	It is difficult to know whether the self-perception and the perception of the group provide enough data to be useful.
Multiple perceptions important to understand group dynamics.	Profiles only work when every member of the group provides a self-perception and perceptions of all other group members.
Self-perceptions were often close to the perceptions of others.	Can be difficult to extract useful information
Gives a deep insight into a persons perceptions and	

personality.	Often the multiple perceptions give contradictory results.
Individual strengths and weaknesses can be assessed, good for self-recognition and improvement.	Where differences occur between self-perception and other members perceptions, very little can be said without further investigation and enquiry.
Management profiles can help interpret the intention of those being observed.	Need to be used in combination with other methods or followed up by discussion.

SIMPLE MULTIPLE LEVEL OBSERVATION TECHNIQUE (SMOT)

Strengths	Limitations
Simply makes use of different perspectives from different participants and researchers, using different research tools to collect data on the same topic or subject in a meaningful and manageable way.	Initially, there is some difficulty understanding how multiple level observation techniques work. After some instruction and reading the difficulties are overcome.
Gathers multiple observations using both quantitative and qualitative tools and techniques.	If questions or topics are vague then participants may misinterpret them.
Provides a reliable source of data (coming from multiple points, participants, researchers, observers, and evidence collected after reviewing the video footage).	Timing of any personal reflection by group participants is crucial; reflections vary with time.
Very useful to get a deep insight into a topic.	Good for specific focused investigation, but inevitably misses out other issues that may be important, but not considered.
Provides a broader understanding of what is happening within the group.	
In some cases views are supported and others the views are very different, providing a more meaningful perspective.	
Reluctant communicators may provide deep insight into issues, even though they appear to distance themselves from group interaction.	

TRANSCRIPTION

Strengths	Limitations
Provides a general overview of the meeting.	Time consuming to transcribe.
Audit trail of all of the verbal messages sent. Every sentence and word recorded.	The distillation of video data into words varies. It took one research $5^{1}/_{2}$ hours, another $9^{1}/_{2}$ hours and further researcher 3 days to transcribe 30 minutes footage. One researcher employed a professional audio typist, but still found that it took hours to turn the type into a proper transcript.
Benefits typing and capturing the data, the transcribing process allowed for a better understanding of what was said, helped to understand some group dynamics; this was considered an advantage during the later stages of the analysis.	Some transcribers record more than others. It is a difficult and confusing task to record transcripts, and it is impossible to track every nuance of the conversations.
The transcript and video can also be used with other data, such as Bales IPA, self-perception profiles and Belbin's self-	It is difficult to transcribe muffled speech, people talking over

perceptions.	each other, and attempted interruption.
Useful to focus in on the interaction trait, to analyse in depth. Detailed nuances of the video would be very difficult to follow without the support of the transcript.	Transcripts ignore how the message was sent, body language, eye contact, intonation, tone, emotion and humour.
Once the classification data identifies certain tendencies, these can be investigated in greater detail using the transcripts and videos.	Unless the research is strongly tied to the transcriptions, there may be a limited need for a transcript. Considering the time it takes to produce the transcriptions, some thought should be given as to whether this is a worthwhile exercise.
Time frames should be recorded on all data so that they can be easily compared and cross-referenced to other data.	On its own the transcript does not really constitute a systematic study.
After repeatedly watching video footage, a general distinction of the contribution of each member can be made and evaluated, for example, the frequency of each speaker, arguments and other occurrences.	Transcripts fail to record who the message was sent to.
	When analysing the data, looking for specific quotes or searching through the data can be a painstaking procedure.
The method produces a qualitative piece of work that is a useful reference document, but it is sometimes hard to locate the piece of transcription that you are looking for. It is important that appropriate coding is used.	Some observers add their own observations to the transcript, introducing an element of subject interpretation into the raw data.
Video data and transcripts are useful for those who are less familiar with the language – foreign researchers, observers from different industries and professional backgrounds.	Transcripts compiled by different researchers are often slightly different.
	Transcripts should be used as a secondary tool, in combination with the video to see how the 'live' communication took place. It is easy to create the wrong picture by just looking at the transcript or video data.

DISCUSSION

The use of research techniques by the postgraduate students has provided a useful insight into their perception of the various methods' strengths and weaknesses. Some of the strengths and limitations may seem basic to more experienced researchers; however, it is clear to the authors that some researchers tend to overlook such issues. It is useful to note that even the most basic data sets, such as transcripts and video data, experience some variation in quality and detail, which may compromise the validity of the data. Indeed, if observers start to add their own comments to transcripts they are no longer verbatim records and the validity of any subsequent analysis would be questioned.

Unexpected aspects of the findings were the problems experienced with fundamental research processes and data sets, such as the use of video and transcripts made from the video. Complicated classification systems, such as IPA (Bales 1950) and SYMLOG (Bales, Cohen and Williamson 1979) involve considerable instruction on how to apply and use the methods, it is taken for granted that people know how to compile transcripts or use video footage, yet the results show that there is variation in how such data is collected, compiled and used. Generating transcripts from group discussion does require some thought. There are some questions to be addressed. When more than one person is talking, should attempts be made to record one or all of the discussion; should just the most prominent speaker be recorded or attempts be made to record statements or partial statements made by others talking at the same time? Should utterances that do not make sense, and may not be complete words be recorded? One thing is certain, to produce the most realistic set of results, researchers should not be adding their own interpretations or comments when collecting data. If transcripts are to be coded for analysis it must be clear that these do not form part of the original data.

When gathering data using any research tool or method it is important that it is made clear how the data is being collected and the exact nature of what is recorded. If using transcripts, the rules for transcription should be stated. When transcribing data, some researchers may be interested in the interruptions and how individuals gain the floor, this would influence the nature of data collected. In such situations, researchers would be particularly keen to analyse periods when parties are talking at the same time and may attempt to pickup and analyse every utterance and attempt at interaction, no matter how incomplete it may be considered. Whereas, other research looking at interaction trends may have little interest in brief statements that are grammatically incomplete. The underlying issue that emerges from these results is that no matter how basic the research method, the rules that govern its application should be stated so that others can apply the method and analyse the data consistently.

CONCLUSIONS

It is clear from the results that in order to find out what is going on the researcher must be able to enter the environment and extract appropriate data. Before the data can be extracted the researcher must ensure that s/he has the necessary tools, knows how to use them and has agreement from the participants that data can be used and analysed for research purposes. It is crucial to identify as many of the limitations before commencing a study, otherwise a considerable amount of time and resources could be wasted. Assumptions that lead to the use of a methodology are often misleading and the only conclusion drawn is that the method used to collect data is inappropriate for the situation studied. The systematic approach to research can be frustrating; however, reviewing studies that have used and tested research methods can save considerable time. This small study has provided a useful insight into a limited number of research tools, but more research is required in construction to identify the most appropriate methods and hence start to build up a scientific body of research into group interaction in construction.

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THE DEVELOPMENT OF A HUMAN-CENTRED WORKING METHOD FOR DESIGN MEETINGS

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Abstract
The problem today in the building industry is that the client and society do not get the values they want. Client values are profitability, usability, flexibility and quality, while society wants to save energy and avoid waste and pollution. One of the underlying problems is that there is a lack of specific working methods for expert designers to work with one another and with clients. A particular human-centred working method is to be developed and tested for design meetings to help solve the problems referred to above.

Keywords: Constructing objects, Design meetings, Human behaviour, Metaphors, Working methods.

INTRODUCTION
This paper describes the initial results of a study aimed to enhance the multidisciplinary collaboration during building design by studying the cognitive processes between expert designers during design meetings, such as the perceptive, the creative, the communicational, the learning and also the emotional and the teamwork processes (Tschimmel 2004). The result of the study will be a particular working method that may help solve the problems in the construction industry.

PROBLEMS
Research shows that building users are increasingly dissatisfied with a building's performance. One of the underlying reasons could be that the expert designers lack the competence and support systems to design in a collaborative way (AWT 2000; ARTB 2000). This can lead to a building design that is an addition instead of an integration of design results. During the initial phase of the design process, the expert designers have to take a great many aspects into consideration and weigh up the value of each of these aspects. However, the expert designers lack the competence to do so. Expert designers in the building design domain are, for example, architects, urban designers, structural engineers, building engineers, process designers, contractors, installers and building physicists.

GOAL
Researchers have found that particular interventions during design meetings can lead to better building performance. Friedl (2001) found that it is necessary to organise and manage the design process. The quality of the design depends on the social process in which participants engage and the competence of the specialist designers working within 'object worlds' (Bucciarelli 2002). Higher levels of positive emotional interaction (by agreeing and showing support) tend to be associated with positive group outcomes (Gorse 2002). The paradigm of the 'Reflective Practitioner' (Schőn 1984) gives the designers a language to communicate with one another (Dorst 1997). The design activities naming, framing, moving and reflecting structure the design process (Valkenburg 2000; Reymen

2001). To obtain the desired interaction, the group had to work alternately in a generative and focusing mode (Hohn 1996). The goal of the study is to contribute to the enhancement of multidisciplinary collaboration by providing a working method for design meetings (Figure 1).

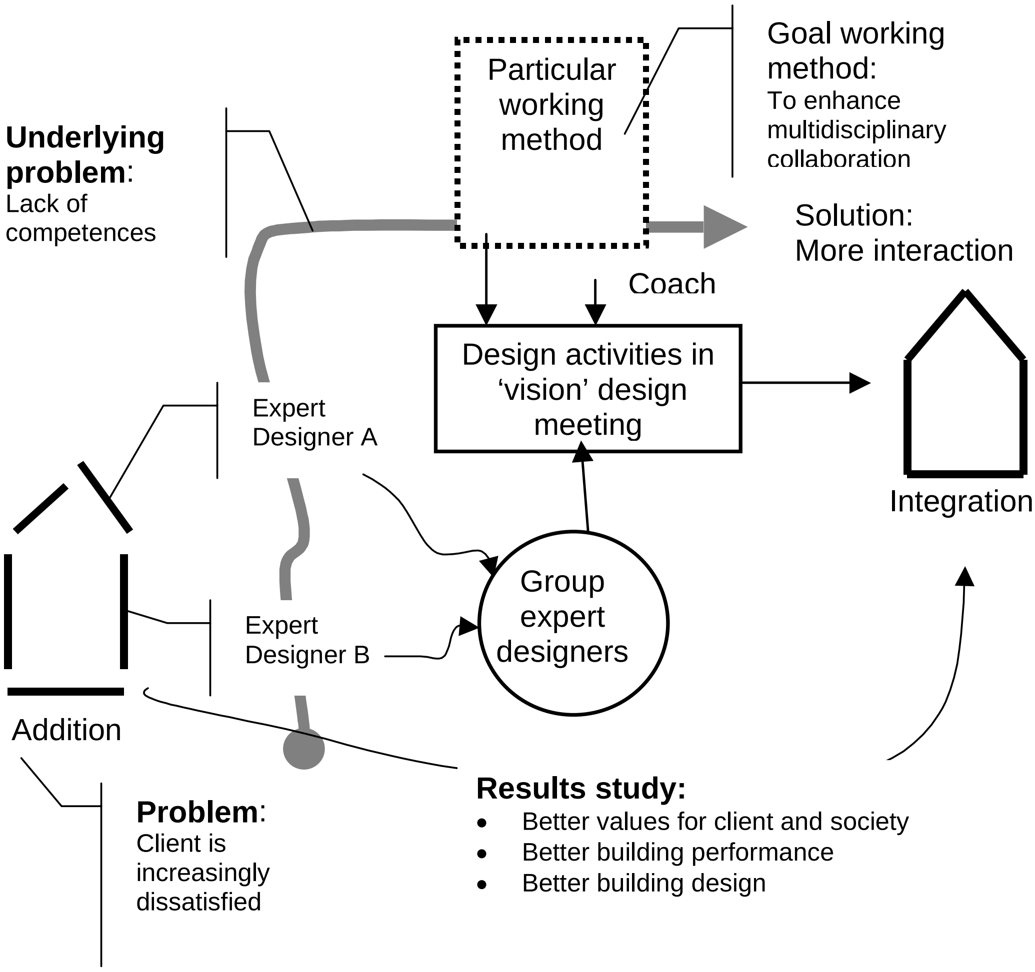

Figure 1 Study field

LITERATURE SURVEY

To attain the goal referred to above, it is necessary to know what we mean by expert designers, knowledge, multidisciplinary collaboration, design meetings, design group, coaching and design activities (by means of a literature survey in this section), and what the interaction is between the designers (by means of an interaction model in the next section).

Expert designers

A competence is a combination of knowledge and insight, skills, personal characteristics and motivation (Plantinga 2004, p. 8). Working as an expert designer in a collaborative way requires a specific competence profile. Dreyfus (2003 cited Dorst and Reymen 2004) distinguishes seven distinct levels (from 1 to 7) of design expertise, corresponding with seven ways of perceiving, interpreting, structuring and solving problems. The expert designer is ranked at level 5 and is described as follows: 'the real expert responds to specific situations intuitively and performs the appropriate action straightaway. There is no problem-solving and reasoning that can be distinguished at this level of working. This is actually a very comfortable level to be functioning on and a lot of professionals do not progress beyond this point.'

To work in a collaborative way in a group, these design expertises are not enough, but the designers must also be competent in co-operating and communicating. As described by Meijers et al. (2005), this '…has the competence of being able to work with and for others. This requires not only adequate interaction, a sense of responsibility, and leadership, but also good communication with colleagues and non-colleagues. He or she is also able to participate in scientific or public debate'. These competences are required for working in a collaborative way. But each designer has his own expertise. Gardner (1993) distinguishes eight kinds of intelligence:

- Verbal linguistic intelligence (Poet)
- Logic-mathematical intelligence (Scientist)
- Visual-spatial intelligence (Artist)
- Body kinaesthetic intelligence (Dance)
- Naturalist intelligence (Naturalist)
- Interpersonal intelligence (Freedom fighter)
- Intrapersonal intelligence (Psychologist)
- Musical/rhythmic intelligence (Composer)

Each person, such as a designer, has his own strong profile. It can be a barrier to working together but it can also cause changes that strengthen each other by using all these competences as much as possible.

Knowledge

The knowledge of an expert designer is mainly accumulated through experience. Nonaka and Takeuchi (1997) called it 'tacit knowledge' and say that this kind of knowledge is difficult to express in a formal language. To exchange 'tacit knowledge' first requires 'socialising': 'feelings, opinions and mental models of the relevant designers had to be exchanged to build up mutual trust'.

Multidisciplinary collaboration

Kvan (2000) distinguishes between the terms collaboration and co-operation. He notes that 'co-operation' relates to working together for mutual benefit, while 'collaboration' relates to working together to achieve shared goals. Kvan also distinguishes closely coupled design processes from loosely coupled design processes, where participants each contribute expertise from their particular domain at moments when they have the knowledge appropriate to the situation. In a closely coupled design process, the participants work intensively with one another, observing and understanding one another's moves, the reasoning behind them and the intentions. Kvan's description explains the meaning of multidisciplinary collaboration.

Design meetings
Reymen (2001) described 'a design session as a period during which one or more designers are working on a subtask of a certain design task', and 'a design task at a certain moment to meet the design goal at that moment, starting from the current design situation. A design task is performed by design activities.' We use some concepts from these descriptions to explain what we mean by a design meeting, viz. a set of prepared design activities performed by a group of designers to work face-to-face on a design task with the help of a coach and support systems to reach a transferable design result. In 'The creative workshop method' Emmitt (2004) distinguishes six types of workshops:

- (partnering) building effective relationships: team-building, common goals, ethics in co-operation, roles and partnering agreement
- vision: basic product values, knowledge and experience, whole-life approach
- realism: fulfilling project values, design alternatives, project economy
- criticism: presentation of conceptual design, value reflection
- design planning: production information, delivery, value engineering
- planning for execution: process plan to map the various production activities

This development of a working method will focus on the 'vision' type of workshop, where the designers sit at a table. This type of workshop requires a shared understanding between the designers of product and process. In his comment on the 'vision' workshop, Christoffersen (2004) mentioned the following aspects: frame and process, dreams and visions, value debacle, value base and evaluation of the 'building effective relationships' workshop.

Design group and coaching
Expert designers working together during a meeting form a cross-functional group. In subsequent meetings, the composition of the group can be different. This is why we do not focus on teamwork or team development with the relevant aspects such as forming, storming, norming, performing and adjourning (Robbins 1998, p. 242) within a programme of design meetings. What we do is to focus on an effective and efficient group process and try and achieve it by careful preparation and coaching within the context of *one* meeting. The role of the coach is crucial. The task of the coach is to provide 'a style of support in which the expert designers come into action by themselves' (Lingsma 1999, p.12).

Design activities
During a design meeting, a coach can let the designers perform a wide range of design activities, which are necessary to attain a certain design result. A number of activities may be suitable for 'vision' design meetings and are based on the existing insights and theories of cognitive processes, such as perception (verbal, visual and tactile), communication, (creative) thinking, (experiential) learning and (interdisciplinary) collaboration.

By harnessing people's creativity, Sanders and William (2001) identified several forms of human behaviour: Say (say, think), Do (do, use) and Make (know, feel, dream).

Each level of knowledge (explicit, observable, tacit and latent) requires a carefully chosen technique (interviews, observations and generative sessions) (Sleeswijk Visser et al. 2004). Sanders (2001) writes: 'The creativity-based research tools enable creative expression by giving people ambiguous visual stimuli to work with. Being ambiguous, these stimuli can be interpreted in different ways, and can activate different memories and feelings in different people. The visual nature liberates people's creativity from the boundaries of what they can state in words. Together, the ambiguity and the visual nature of these tools allow people much more room for creativity, both in expressing their current experiences and ideas and in generating new ideas.'

Creativity techniques make tacit knowledge of designers explicit. Root-Bernstein et al. (1999) used a trans-disciplinary view to define creativity: 'Creative thinking in all fields occurs preferably before logic or linguistics come into play, manifesting itself through emotions, intuitions, images and bodily feelings. The resulting ideas can be translated into one or more formal systems of communication such as words, equations, pictures, music or dance only after they are sufficiently developed in their prelogical forms.'

To express the latent and tacit knowledge of the designers, creative thinking with the aid of creative techniques is useful for a vision-based session. The purpose of a 'vision' design session is to reach an agreement between the different designers about the process and product. This means that the designers create and share knowledge. In educational terms, they learn from one another. A generative or creative technique to help achieve this purpose should be a philosophy called 'serious play'. Serious play is a serious activity to create innovative ideas. Schrage (1999) describes the essentials of serious play as follows: 'Serious play is about improvising with the unanticipated in ways that create new value. Any tools, technologies, techniques or toys that let people improve how they play seriously with uncertainty are guaranteed to improve the quality of innovation. The ability to align those improvements cost-effectively with the needs of customers, clients, and markets dramatically boosts the odds for competitive success'. John Varney (2005) gives a special meaning to 'serious play'. SERIOUS refers to the left brain (logical, analytical, fragmentary, mechanical, efficient) and PLAY to the right brain (imagination, pattern-forming and recognising, holistic, organic, effective).

Papert (1999) says, 'Constructionism is the idea that knowledge is something you build in your head. Constructionism reminds us that the best way to do that is to build something tangible – outside your head – that is personally meaningful. Furthermore, that knowledge is best constructed in a social context where the participants make something sharable.'

In his inaugural lecture Martens (2005) says that people use two complementary means for communicating ideas, opinions and interactions. 'Descriptions' for spoken and written languages and 'depictions' for gestures, drawing a picture, images and sketches. The last means is helpful for forming opinions and ideas, where the opinion is not determined by externally agreed interpretation. In our view, it does not stop with drawing pictures, but constructing objects is also a helpful means. It is probably a matter of tactile intelligence or tactile thinking as a counterpart to conceptual thinking. Donald Schön (1992) tells us that ‘Design knowledge is knowing-in-action’. Constructing with materials helps the designer express the knowledge that he cannot say.

Designers’ interaction circle

Designing is a social process. This means that designers communicate with one another. A designer shows what he thinks (by acting) and gets a reaction from another designer (by reacting). What a designer thinks is based on his mental model, a representation of reality that is built in order to understand, predict and explain the world (Badke-Schaub 2004). By integrating acting (doing, skills), reacting (feeling) and thinking (knowledge), the experience can grow (Dewey 1958) and the mental model change. Reflecting is a special kind of experience, namely an experience with regard to one’s own experiences. It is a crucial phase in a learning process (Kolb 1983) and in a design process.
The acting and reacting activities can be performed in a wide range of languages (Birkhofer and Jänsch 2003, p. 106) and can be disturbed by a specific barrier around the designer. Buciarelli (2002) called this the ‘object world’. Designers can have their own language, tools, codes, unwritten rules and scientific paradigm. The acting and reacting activities are described in detail in the designers’ interaction circle (see Figure 2). We call a coherent collection of acting and reacting activities a working method.

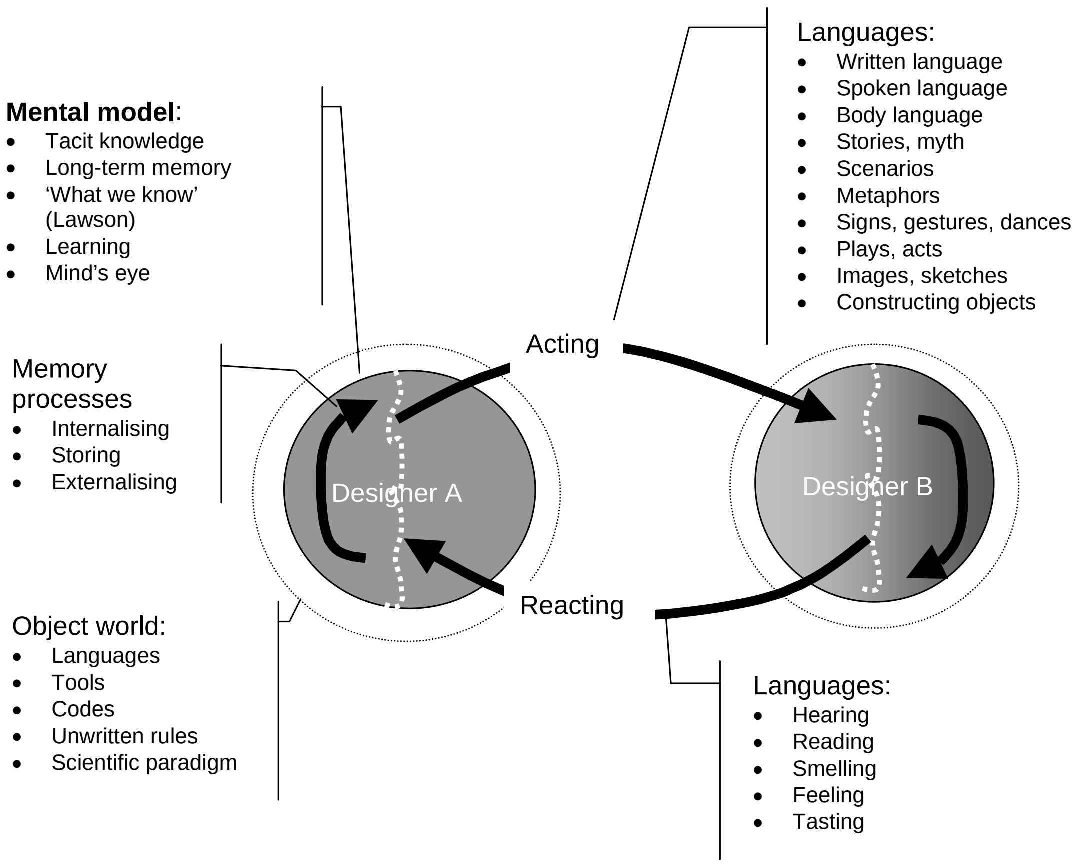

Figure 2 The designers’ interaction circle

PARTICULAR WORKING METHOD

Researchers believe that designers who work together effectively produce more knowledge and share more tacit knowledge, and that it is necessary to organise and manage the design process (Friedl 2001). Use of a working method specifically for a face-to-face 'vision' design meeting with expert designers is one way of achieving this. The particular working method is a set of coherent design activities, which consists of a wide range of acting and reacting languages, and has been developed on the basis of the following design parameters:

- Using the rational and tacit knowledge of the designers
- Using the left and right brain alternately
- Using description and depiction
- Using a wide range of intelligences
- Using visual and conceptual thinking
- Learning from one another
- Taking time for reflection
- Constructing metaphoric objects with one another
- Working in a generative and focusing mode
- Taking time for incubation

Two parameters need some further explanation. 'Visual thinking is thinking in images and events. It can be described as spatial thinking. Visual thinkers prefer to organise their world with non-linguistic means. They see mental images or situations and events, in which several things are visible at the same moment, interact with one another and form a meaningful entity. It is simultaneous, non-verbal thinking, a manipulation of spatial events. Most visual thinkers have a holistic cognitive style, which means that they are 'good' in not losing themselves in details, in the discovery of co-ordinating relations and in giving personal, biased total descriptions of problems.' (De Groot and Paagman 2003, p. 85). This description may indicate that building designers are more visual thinkers than conceptual thinkers. Incubation requires some explanation. Design meetings held with expert designers have shown that for complex design tasks, the designers need an incubation period to find ideas and concepts (Van Gassel and Rutten 2004).

A wide range of design activities can be developed using these design parameters as a basic premise. A division into the following categories can be made: constructing objects, writing, mapping, sketching, storytelling. playing, acting, reflecting, releasing and relaxing. Some activities are well known but others have been specially designed, such as 'constructing objects'. This activity is explained in more detail in the next section.

CONSTRUCTING OBJECTS

Constructing objects is part of a design meeting with the following steps:

1. imagining oneself in the problem, getting a feel for the problem
2. formulating the design task
3. generating new visions by constructing an object
4. formulating an answer to the design task

Step three, constructing objects, comprises the following activities:

- constructing an object together with special materials

- explaining what you are doing and giving meaning to the objects
- listening to the opinions of the other designers
- presenting the significance of the object to one another
- describing the significance

The materials required to construct the object are well chosen. Tests show that the materials cannot have a meaning on their own. During construction, the designers will give the object a specific significance by telling stories. We call the object with that specific meaning a metaphoric object. A metaphoric object is a transfer of meaning between two domains: a source domain (from which the metaphorical expressions are drawn) and a target domain to be understood (Lakoff 1980). In step 4, this meaning is to be transferred to a design result as an answer to the design task. The activities 'constructing an object and telling a story about it' are an attempt to inspire and stimulate the designers to work in a rational and emotional way. The opportunity to get innovative and share solutions should be greater (Bijl 2002).

Experiences with constructing objects

Van Gassel (2005) describes tests with the 'constructing objects' activity. The designers (in these tests novices and advanced beginners) were interested in participating in this kind of design activity: they like it, find it easy and fun and they learn from one another. 'Developing an answer to the design task was difficult' and the designers were also not really satisfied with the design results. The conclusion was to find another way to transfer the ideas generated from the source domain to the target domain. A group of designers (novices and advanced beginners) experimented with the 'constructing objects' design activity to develop a shared vision for a compact campus. One of the participants quoted his experiences in his reflection report as follows: 'The creativity method used was not known to the participants involved with the session, which led to a misinterpretation of the assignment. As a result, the campus was not visualised in the conceptual or metaphorical way as intended. Neither did people explicate or communicate their ideas effectively, complicating effective adaptation and improvement of ideas. Since people seemed very involved with the playthings, it was hard to bring the group to an effective shared interpretation of the task' (Goossens 2005). Initial experiences with the 'constructing objects' design activity carried out by expert designers has given the indication that the embedding of this activity within the design meeting had to be carefully programmed. An assignment designed to get the group involved in the 'constructing objects' design activity is necessary.

NEXT STEPS

The next steps in this study are:

- To set up a model for design meetings, working methods and design activities, as an enlargement of the designers' interaction circle.
- To develop a guideline, including strategies and heuristics (Badke-Schaub and Stemple 2003, p. 130), to use the particular working method and a workshop to learn to use this method.
- To test the particular working method in the building industry with the aid of expert designers to determine the benefits.

The measuring of the design activities during the face-to-face design meetings will be carried out by video interaction. The determining factors are the type of design activities and the socio-emotional interaction according to the Bales method (Gorse 2002). The supporting emotion, offering information, asking questions and negative emotion will be measured. A higher level of positive emotional interaction tends to be associated with positive group outcomes. At the same time, various external conditions had to be measured to gain an understanding of how external factors such as the character of the expert designer and the design task and design result influenced the design activities.

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COMMUNICATING DETAIL

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Abstract
Production information is central to the construction industry. Deficiencies in its creation or errors in its interpretation can lead to costly remedial work or even litigation. Early research in the UK into the quality on building sites led to the establishment of Codes of Procedure and Standards to provide a common language to aid communication between construction professionals. However, this framework has not provided an adequate solution as significant problems persist. This paper identifies issues associated with the creation and utilisation of production information by both designers and constructors. These are evaluated to establish the underlying reasons for the failure of construction professionals to adequately communicate and interpret detail. Academic theory and published information are compared with industry opinion to confirm the contributing factors and demonstrate their inter-connective nature. In addition, the application of standard practice is investigated. The underpinning research reflects a successful undergraduate dissertation and provides a platform for further investigation. There are several key findings and recommendations. Education, both initial and continuing professional development, must raise awareness of the Codes of Procedure and Standards initially introduced to address the problem. Furthermore, professionals must competently exploit information technologies to increase productivity. Effective design management systems are needed for checking and coordinating information, also allocating sufficient time and suitably qualified staff to undertake these tasks. Behavioural factors, that contribute to the under valuation and disregard of production information have been identified. Finally, this research shows by an examination of UK contracts in common use, that there is an urgent need for a mechanism to enforce the use of co-ordinated project information.

Keywords: Communication, Common language, Coordinated project information, Production information

INTRODUCTION
The Building Research Establishment (BRE) state that remedying construction defects costs the UK industry at least £1 billion a year and that communication of production information including poorly detailed drawings is largely responsible (Stupart, 2003). Construction activity usually involves the coming together of several parties to procure a project. The designer is not usually the same person as the constructor, therefore effective communication is essential to convey the design intent to those undertaking construction. Failure in this process can result in errors, time wasted and costs incurred (Emmitt & Gorse, 2003). The designer creates instructions for the builder in the form of production information. The term production information will be used throughout this paper to encompass architectural working drawings, schedules, specifications and bills of quantity. The full range of production information is usually required in order to communicate the necessary level of detail. Like language, production information is open to misinterpretation, lack of clarity, and ignorance.

The intention of this paper is to examine the status of production information and question whether it holds sufficient value within the industry. This encompasses the resources, care and effort put into the creation of production information, the translation and possible disregard of that information and any external influences.

LITERATURE REVIEW

Recognition of the Problem

Throughout the 1970s and 80s the Government funded numerous research projects in order to establish the origin of building defects and to determine how they could be avoided. The Building Research Establishment (BRE) observed the site quality control process on 50 projects for both private and public sector works under a variety of procurement routes. The findings of the research were published in 1987 by the National Economic Development Office (NEDO) under the title "Achieving Quality on Building Sites". The research findings showed a high incidence of late and incomplete project information. Evaluation of the research showed a correlation between the quality of the production information and the finished building. Nearly 30% of all quality problems and 15% of serious quality problems were the result of unclear or incomplete project information (NEDO, 1987). The industry acknowledged the problems highlighted in the NEDO Report and reacted by establishing a framework for co-ordinated project information.

Establishing the Framework

Following recommendations made in the NEDO Report, the Association of Consulting Engineers (ACE), Building Employers Confederation (BEC), Royal Institute of British Architects (RIBA) and the Royal Institution of Chartered Surveyors (RICS) collaborated to form a committee whose aim was to prepare practical guidance for designers and publish universal procedures for the creation of production information. The group is currently known as the Construction Project Information Committee (CPIC) and since 1987 it has published and maintained the guidance for co-ordinated project information (CPI). This sets out the codes and procedures to be followed when creating production information. There are several British (BS), European (EN) and International standards (ISO) that set out good practice and procedure for the creation of production information using the same principles published by CPIC. The standards also provide a common language by means of standard symbols and abbreviations to be used in project information.

The Use of a Common Language

The language laid out in the standards and codes of procedure is made up of symbols (vocabulary) and conventions (syntax) and the designer must uniformly apply these in order to be interpreted fluently by the constructor. Authors such as Liebing (1999) provide comprehensive practical guidance on the presentation of information through text books readily available to students and professionals. Liebing (1999) recognised that both the originator and the recipient must be familiar with the language in order to achieve effective communication and states that any abbreviations must be commonly accepted throughout the industry. He also points out that there will be occasions where there is a need to deviate from the standard vocabulary and in such instances there must be additional clear definitions displayed in legends (Liebing, 1999).

Emmitt and Gorse (2003), who have an academic interest in communication within the construction industry, reiterate the need for the strict application of a universally adopted language to clearly convey design intent. Advocating the precise and consistent use of words and symbols to avoid ambiguity, the researchers stress the importance of accuracy in order to prevent confusion and error. Regardless of the use of either standard symbols and abbreviations or annotating non-standard items, designers should use the same format consistently throughout and across the project information. Additionally, Emmitt and Gorse (2003) indicate that even if the designer creates a faultless set of production information, it is useless unless the constructor has an appreciation of design principles and is familiar with the conventions used to convey the requirements.

Education

Gorse and Emmitt (1999) have made the observation that in order for communication to flow, everyone must be fluent in the language. As people from many disciplines need to come together for a construction project, every type of professional must be familiar with the same standards, be able to recognise the symbols used and interpret the instructions in a similar way. There are observations in the literature about the inadequacies of education and concerns that courses do not adequately cover the correct practice for creating production information (Snook, 1995; Coles, 1990). Shortcomings, it would appear, are in the initial education of professionals entering the construction industry (Snook, 1995), and also in the Continuing Professional Development (CPD) of those professionals already in practice (Coles, 1990).

Initial Education

In his paper on co-ordinated project information, Snook (1995) expressed his disappointment that very few schools of architecture teach CPI. Although appreciating the pressures on curriculum time, he thought it unreasonable for teaching institutions to release graduates into the work place without the skills fundamental to practice. His findings suggest that initial education may be lacking and failing to provide the necessary skills and knowledge required by designers to create accurate and complete production information. The industry also seems to acknowledge shortcomings in the education of the constructor with regard to the correct reading and interpretation of production information. When the journal Construction Manager (March 2003) published the findings of their 2003 survey into graduate recruitment within the construction industry, reporter Chrissie Chadney concluded that generally, those surveyed expressed a high level of dissatisfaction with the quality of graduates and particularly with their lack of basic technical competence (Chadney, 2003). Dissatisfaction was expressed about essential skills such as taking off, reading of drawings and quality control. Chadney (2003) reported that the general view was that students who came up through the trades or via day release were preferable to those who had only undertaken academic study.

It is not just the responsibility of universities to ensure that designers can communicate effectively but also the responsibility of building colleges and universities to ensure that construction professionals can translate the information accurately. Fluent translation relies on the reader being familiar with the standard symbols and abbreviations used by the designer.

Continuing Professional Development
Professional institutions place a mandatory obligation on their members to maintain current awareness through life long learning and continuing professional development. Coles (1990) suggested that CPD could alleviate many of the problems associated with production information, improving the training of professionals currently in practice. However, it is suggested that CPD fails to focus on the process of creating production information. Emmitt and Yeomans (2001) state that CPD seminars are generally delivered by individual companies who are interested in selling their product or service and not in developing the skills of the designer. There are insufficient seminars held by subject experts aimed at the process of conveying detailed information successfully.

Time and Cost
The level of detail to be communicated in production information is, by its very nature, time consuming to produce. Therefore, sufficient planning is essential to enable adequate resources to be assigned to the task. Chappell and Willis (2000) advise that time should be allotted accordingly. As the documents and drawings form part of a legal agreement on works to be undertaken, the authors warn that vagueness and uncertainty could expose the project sponsors to claims for extra payment.

According to Emmitt (1999), designers are more interested in the conceptual design stage rather than in the laborious detail of creating production information. Researchers Emmitt and Yeomans (2001) found that low priority was afforded to the planning and preparation of project information and expressed their surprise at the lack of time assigned to this crucial task. A suggested reason is that earlier stages in the design process, those perceived as being more creative, frequently exceed time schedules and subsequently production information, created in the latter stages of the design process, is often curtailed. Designers regularly enlist junior staff to create detailed information in an attempt to cut costs and relieve themselves of tasks they regard as mundane. However, Emmitt and Yeomans (2001) consider this to be a false economy as much time can then be wasted in correcting errors or looking for missing information. Therefore, one could argue that the involvement of highly qualified and experienced staff could greatly improve the quality of production information and reduce overall costs by eliminating the need for remedial work.

Even well established authors of textbooks like Liebing (1999) prescribe devoting time and attention to the production information stage. Aware that architects deliberately devise methods to save time and increase productivity, Liebing warns of the risk that short-cuts can result in errors and omissions endangering a project both structurally and economically. Liebing (1999) considers this problem to be further compounded by insufficient time allocated for meticulous checking of information prior to issue.

An effective way of saving time whilst maintaining quality is to implement a set of office standards and master specifications. The use of standardised solutions offer a tried and tested method that reduces risk, provides time and cost benefits and maintains quality levels. A proper library of master specification clauses and standard details must be continually maintained so that they evolve as industry standards and regulations change. Thorough checking is essential, so that errors are eliminated rather than perpetuated by re-use. Even if a design office employs this method, care must be taken in the management of its application. Emmitt (2002) observed that inexperienced members of staff are often left unsupervised and he advised the use of strict managerial control to ensure the correct application of details to avoid the risk of costly errors.

Computer Aided Design and Information Technology

The last thirty years has seen the transfer from hand draughting to the widespread use of Computer Aided Design (CAD) and other information technologies (IT). It was widely believed that the introduction of CAD and IT would facilitate speed and accuracy in the production of design detail. However, CAD is not without problems and Liebing (1999) raises a number of issues. He warns that CAD appears deceptively easy to use, but as a sophisticated tool, time must be taken to learn how to properly utilise the package. He considers the apparent ease of use can lead to insufficient care in its application with details being created quickly and in a mindless manner leading to later problems on site (Liebing 1999).

Co-ordination

It is rare for only one designer to carry out design work. Textbook authors Seeley and Winfield (1999) see the crux of the problem as being that different types of information are provided by a variety of offices of different disciplines. This involvement of external consultants from multiple disciplines further complicates matters. Therefore, only the most efficient cross-referencing and co-ordination can bring control to such a potentially problematic situation. Liebing (1999) states that it is vital that all production information is conscientiously cross-referenced to facilitate ease of retrieval and to enable navigation from one location to another source that contains the level of detail required. Nurden (2003) also states that even if the designer has created a detail, if there is no reference to its location, it may never be used.

Checking

Time constraints and the failure to acknowledge the importance of high quality production information often result in checking being given a very low priority. Emmitt and Yeomans (2001) carried out a postal survey and found that problems occurred due to inadequate checking as a result of rushed working practices. Emmitt and Gorse (2003) advise that checking should be a continuous process throughout the design stage and carried out by all parties involved to reduce subsequent problems on site. The information should be thoroughly checked for compliance with current codes and standards, manufacturer's recommendations and other consultants' information. They warn against self-checking and recommend the use of quality management systems. Emmitt (1999) expresses surprise at the lack of formal checking procedure employed by many architectural offices.

Misinterpretation and Disregard

Emmitt and Yeomans (2001) suggest that unless the information provided is completely clear and well co-ordinated there is a danger that site personnel will become frustrated and disregard the information, thereby misinterpreting the design intent. Research (NEDO 1987) has shown that on projects where the production information supplied was inadequate, constructors were seen to be reluctant to seek clarification and distorted the message by devising their own solutions. The findings suggested that contractors often gained a certain job satisfaction from completing a build with insufficient information.

Gorse and Emmitt's research (1999) highlighted the problem of professionals perceiving the need to ask for help as a loss of power or status. They found that both construction managers and architects admitted that collaboration would have greatly benefited the projects, but they had been reluctant to make contact even though they did not have sufficient understanding to make an informed decision. Although some production information is sub standard, there may also be behavioural reasons for the disregard of a designer's instructions.

Summary of Literature Review

This review of the literature has highlighted areas of concern regarding the production and interpretation of production information. In particular the degree of education, knowledge, checking and time are of significance.

METHODOLOGY

The paper, which focuses on the UK construction industry, identifies the current relevant codes of procedure and standards available to professionals when creating and reading production information. A literature search was undertaken to establish academic theory. An examination is also presented of both the conditions of engagement for the appointment of designers and standard building contracts for constructors to undertake building works. This establishes the provisions made under contracts to ensure the quality of project information and illuminates the reasons for inadequate adoption of CPI.

The issues raised by the literature review were used to form the basis of interview questions posed to three typical professionals in working practice in order to gauge industry opinion. It is acknowledged that this restricted sample cannot provide a comprehensive account, however it provides an indicative view of the current state of affairs. An architect, a construction manager and an architectural technologist were selected for interview, as their roles require them to each take a different perspective of production information. The architect prepares information as a designer. The contractor reads the production information as a set of instructions on how the building is assembled. The architectural technologist provides a link between design and construction. Local companies carefully selected to meet the criteria of the required population were and contacted to identify professionals willing to participate; the interviewees were randomly selected from those who responded positively. A semi-structured approach was taken in order to both confirm ideas arising from the literature and research and also to allow for further exploration of the issues through discussion. The interviewees were asked to draw on their experiences and express their opinions on the issues associated with the creation and reading of production information. Although information gained from the interviews is subjective, the interviewees formed a representative sample.

REVIEW OF ENFORCEMENT OF STANDARDS

The industry responded to the recommendations of the NEDO Report (1987) by establishing a framework for co-ordinated project information (CPI). In his report Constructing the Team, Latham (1994) recognised how beneficial CPI was to building projects and felt its adoption, as standard practice was well overdue. Latham recommended the use of CPI be made a contractual obligation by its inclusion in the conditions of engagement of designers. This section examines the terms written into the conditions of engagement relating to designers as set out by institutions, clients and Government bodies to determine whether Latham's recommendations have been incorporated. It also establishes whether any provisions are made under standard building contracts to stipulate the quality of the information provided to the contractor.

The Appointment of Consultants

Professional designers are required by their professional institutions to enter into agreement with their clients to carry out services. Designers can use standard conditions of engagement drawn up by their own institute or other bodies. Alternatively, they can work under bespoke contracts drawn up by the client or their legal advisers. The following is a comprehensive list of the conditions of engagement, applicable at the time of writing, to architects, technologists and surveyors in the UK.

The Property Advisers to the Civil Estate (PACE)

The conditions of engagement that designers must agree to upon their appointment to carry out government works are produced by PACE. Their General Conditions for the Appointment of Consultants - GC/Works/5 (1999) – is used for all UK government works and various clauses may be excluded depending on the services required. Clause 1.31 sets outs the mandatory use of CPI and states that the consultant must adopt all necessary practices in utilising the codes of procedure for production information.

Royal Institute of British Architects (RIBA)

Architects who are members of the RIBA, when not using a customised client contract, would be appointed using SFA/99 (Standard form of agreement for the appointment of an Architect) or one of its derivatives. The standard form of agreement is a core document that all other RIBA forms are based upon. Although there is no clause within SFA/99 making the use of CPI mandatory, the RIBA work plan is included in the conditions of engagement. Stage F of the work plan stipulates that production information must be prepared in sufficient detail to facilitate tendering, gain statutory approval and enable the carrying out of works under a building contract. CE/99 (Conditions of engagement for the appointment of an Architect), SW/99 (Small works) and SC/99 (Form of Appointment as Sub-Consultant) are used for more straightforward works, small works, or where being employed as a sub-consultant respectively. The conditions within these documents are derived from SFA/99 and therefore do not stipulate the use of CPI.

The Association of Consultant Architects (ACA)

Membership of ACA is by practice rather than by individuals. ACA/98 - The Appointment of a Consultant Architect is intended for small works, work of simple content and specialist services on projects with an estimated value of under £250,000. Clause 4.05 states that architects will be held responsible for the preparation of all drawings, schedules and specifications and tender information as part of the construction information package. The conditions do not stipulate the use of CPI.

Chartered Institute of Architectural Technologists (CIAT)
CIAT is the professional institute representing Architectural Technologists and is the qualifying body setting their standards and level of competence. The CIAT standard conditions of engagement are intended to clarify the terms of appointment for Technologists. The document does not prescribe any standards for production information.

Royal Institute of Chartered Surveyors (RICS)
The Conditions of Engagement for Building Surveying Services is an agreement for the appointment of Chartered Building Surveyors. In the Building Works section, Stage E, Clause 5.1, states that the Chartered Surveyor is responsible for preparing working drawings sufficient for the construction of the project in co-operation with other appointed consultants. The document makes no reference to CPI.

The Joint Contracts Tribunal Limited (JCT)
JCT provides the Consultancy Agreement for a home owner/ occupier, for use where a householder requires the services of a consultant to carry out home improvement works such as extensions and alterations. A staged plan of work is incorporated and various clauses may be excluded depending on the services to be provided by the consultant. Stage 2 requires the consultant to prepare detailed drawings and a specification for the building works; however the document does not provide reference to standards with which these items must comply.

Client Standard Contracts
Corporate Clients who undertake many building projects may have their own standard contracts that have been drawn up by their legal advisers. The contents of bespoke contracts to be used as a corporate standard may contain clauses relating to the client's previous experience of building projects or may be based on standard formats. Such documents are tailored to the requirements of the individual client and may or may not include CPI.

Building Contracts
The constructor enters into a contract with a client to undertake building works. The most common options in use are Government Contracts, JCT and client standard contracts.

Government Contracts
GC/Works/1 and GC/Works/2 – The drawings, the specification and, depending on the type of contract, the bills of quantities form part of the contract documents. Unlike GC/Works/5 for the appointment of consultants, the building contracts do not express the mandatory use of CPI.

The Joint Contracts Tribunal Limited (JCT)
Under JCT building contracts the drawings and, depending on the type of contract, the bills of quantities for a project are contract documents and therefore form part of the

contract. Under JCT contracts where the contract is based on bills of quantities, clause 2.2.2.1 specifies that the bills must be prepared in accordance with the Standard Method of Measurement of Building Works (SMM7). No specification is given in the contracts for the preparation of the contract drawings.

Client Standard Contracts
As with conditions of engagement for the appointment of consultants, corporate clients may draw up their own standard building contract. These may or may not be prescriptive about the quality of the production information provided to the contractor.

Summary of the Investigation into Standard Contracts
With regard to the appointment of consultants to carry out design work, investigation shows that only the Government has adopted Latham's recommendation to stipulate the use of CPI.

The contracts relating to the undertaking of building works contained no obligation to use CPI for specifications or working drawings. The JCT contracts stand alone in prescribing quality standards for the preparation of bills of quantities.

RESEARCH FINDINGS - INTERVIEWS
Industry opinion was sought to confirm the findings of the literature review and to establish the use of CPI. This comprised semi-structured interviews with three individuals representative of the key professions involved. Although limited, this survey reflects industry practice and serves as a base for further, more extensive, investigation.

Adequacy of initial education: There was a mix of opinion amongst the interviewees who had all undertaken extensive formal education relevant to their discipline. Only the construction manager felt that he had been sufficiently educated in the fundamental skills necessary for the workplace. The technologist, who was educated during practice, said that the majority of his knowledge of detailing had been gained at work. However, he acknowledged that he had failed to understand the relevance of his education until he was in the latter stages. The architect had undertaken an initial five-year full-time degree course and stated that he had not expected his course of study to fully prepare him for work in practice. In his view, the day to day skills such as draughting and administration ought to be acquired during the post qualification period.

The interviewees were also invited to express their thoughts on the quality of graduates currently entering the industry. The construction manager complained that graduates coming from full time study too often have a very high opinion of themselves but are really of little value until they have gained a sufficient level of practical building knowledge. The technologist considered architecture graduates to have vastly improved their presentational skills due to advances in computer software, but claimed they were putting too much emphasis on presentation rather than content. He complained about the architecture graduate's lack of knowledge and skill in detailing.

CPD: Questions were posed about what CPD currently provides and what the interviewees felt it should provide. The consensus of opinion was that CPD seminars are mainly provided by companies using them as marketing tools for their own products. The architect expressed concern that practices may expect their CPD requirements to be solely met by companies who use seminars as business promotional opportunities. It was his belief that individuals should endeavour to keep up with the latest developments in the industry and that employers also have a duty in this respect. The architect then suggested that employers have a vested interest in ensuring that their staff keeps up to date with changing legislation and standards in order to avoid possible litigation. In addition, he felt that it was in the best interests of employers to raise awareness of developments in procedure that may increase productivity. All interviewees agreed that CPD should provide information about modernisation to prevent staff and operatives becoming complacent. The technologist believed that CPD should also fill the knowledge gaps left by initial education.

Time allocated to design: Responses indicated that tight time scales prevail, largely for financial reasons. The architect felt that all projects would benefit from more time but implied that he would use additional time for design development. This would seem to confirm the theory put forward by Emmitt (1999) that the highest status is conferred on conceptual design.

Impact of CAD and IT: Respondents were unanimous about it having speeded up the creation process and the construction manager felt that technology has provided easier and quicker access to information. The architect acknowledged that computer packages have increased the quality of presentation of project information but commented that this sometimes masks inferior content. As designers become more adept with computer software it is possible to manipulate and extract information for integration into new production sets. However, there is a danger that errors can be perpetuated in this way and the technologist raised concerns about the extent of copying without understanding.

Co-ordination of production of project information and site operations: The construction manager and the technologist both stated that the ideal is to have all the information available in one package at the start of the building programme. The architect pointed out that due to time constraints, the common practice is for the constructor to supply the designer with a prioritised schedule of information requirements. This procedure, according to the architect, works well. However, he complained that once the constructor has the information they often make on site alterations without informing the designer. He considered this lack of feedback to be a major breakdown in the communication process.

Co-ordination between components of production information: The three professionals commented on the detrimental effects of conflicting information. The architect felt that problems could be eliminated by adequate checking procedures but these were generally omitted due to time constraints.

Checking: The interviewees reported considerable variation in the degree of checking carried out. Although all three interviewees felt thorough checking is the ideal they acknowledged that it is far from universally adopted. The architect confessed that checking information produced by other members of the design team is very uninspiring and commented that the expectation was for professionals to be responsible for the accuracy of their own work.

Misinterpretation of production information: All three interviewees reported that they had witnessed regular occurrences of both misinterpretation and disregard and went on to conjecture about the underlying reasons. The architect highlighted conflicting and poor quality technical information as major factors in misinterpretation. Both the architect and the construction manager believe a lack of education is largely to blame. The architect and architectural technologist also gave a number of behavioural reasons for the possible disregard of production information. They suggested that contractors might be unreceptive to unfamiliar methods of working and, according to the architect, sometimes even unwilling to read the drawings and specifications. The architect went on to say he had encountered some particularly unyielding contractors who felt their knowledge of construction was greater than the designer's, and admitted that in some instances this was the case.

Standardisation: Opinions were sought about the extent to which standardisation had been adopted. A number of questions were posed regarding the structure of information and the clarity and consistency of symbols and abbreviations. The architect felt that information was insufficiently structured and inconsistent and greater standardisation would be beneficial. In his experience, standardisation is not readily adopted in architecture; however certain other disciplines such as engineering avoid ambiguity through greater implementation of standards. In the architect's opinion CAD and IT had contributed to standardisation but were not used to their full potential, as designers did not employ standard libraries of symbols. He believed that productivity could be greatly increased through the implementation of such standard libraries. The architect interviewed gave reference to the approved documents accompanying the Building Regulations and stated that glossary sheets are used to explain symbols and abbreviations. Suggestions were made for the possible use of such glossary sheets in all production sets. At the very least, he felt, all symbols should be keyed on drawings.

The architectural technologist commented that although structures were in place, professionals were either unaware of them or did not apply them. He applauded the use of standard formats of documentation such as the National Building Specification and commented that it was unfortunate that the use of standard formats in projects was not mandatory. The architectural technologist interviewed stated that in his experience, although standard symbols and abbreviations were commonly used they were often attributed with different meanings. This viewpoint illustrates the ineffective use of the established framework for communication.

In the opinion of the construction manager, the responsibility lies with the contractor to check any information on receipt and raise any queries. He confirmed that different companies supplied production information with varying degrees of clarity and uniformity. He commented that there was a vast variation in the presentation of information and it had not improved in his forty years experience.

Standardisation of the format of production information being enforced through contractual obligation was introduced as a concept to the interviewees. The architectural technologist responded positively, however raised doubts about the practicalities of implementation and the reluctance of designers to comply. The architect reacted adversely saying that he would not be enthusiastic as he felt that the industry was already over-regulated. He also voiced his reservations about the legal aspects of writing such conditions into contracts, judging non-compliance and the quantification of penalties. However, the architect did recognise the potential benefits to contractors of the consistency of information that such conditions could enforce. In contrast, the construction manager was in favour of the standardisation of information through contractual obligation.

Summary of Interview Research

The findings from the interviews confirm the views expressed in the literature; in particular the failure of education, both initial and CPD. Additionally, production information is given insufficient support from experienced professionals during the design process. The information is produced hurriedly, given inadequate checking and lacks standardisation and this contributes to misinterpretation and difficulties on site. Although guidance exists to overcome these problems, the research for this paper evidences that it is not widely adopted.

CONCLUSION

This paper has examined the status of conveying detail within the industry and from the findings concludes that insufficient value is placed on production information. There are a number of factors contributing to this longstanding problem:

- Initial education is failing to provide construction professionals with the common language to communicate effectively. Continuing Professional Development seminars are being used by companies to sell products and do little to advance the skills of professionals in practice.
- CAD and IT are currently under utilised and could, if managed correctly, improve quality and increase productivity.
- Although academics advise strict checking procedures, these do not appear to be widely adopted throughout the industry.
- Designers appear to be mainly interested in creating conceptual designs and do not invest sufficient effort in the detailed design stage. The quality of production information would greatly benefit from the involvement of highly qualified and experienced staff. Insufficient time is allocated to this stage.
- The level of quality of production information largely determines the accuracy of its translation.
- Behavioural factors have a negative impact on the use of production information when contractors choose to disregard the designer's instructions.
- There is a failure to adopt management procedures to co-ordinate information originating from multiple disciplines.
- A mechanism is lacking within the industry to ensure the use of a common language. Contracts do not contain sufficient clauses to stipulate the quality of production information.

RECOMMENDATIONS
The following recommendations are made for future development:

- The initial education of designers should be expanded to include the codes of procedure and standards adopted under co-ordinated project information.
- More time to be allowed in the curriculum for construction students to learn how to read production information.
- CPD seminars to be developed aimed at improving the skills of the designer with a view to improving the quality of production information.
- The use of co-ordinated project information should become mandatory through contractual obligation by the inclusion of sufficient clauses into both contracts for the appointment of designers and contracts to undertake building works.

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BOUNDARY OBJECTS FOR DESIGN OF KNOWLEDGE WORKPLACES

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Abstract
Professional service providers and knowledge intensive organisations are constantly searching for ways to improve and add value to their business. This has led to an increased attention to space and to the physical settings in which knowledge work is carried out. Much attention has been directed onto the possible gains by using office design as a tool to achieve organisational goals, such as change and innovation, learning, teamwork, e.g. This paper, based on cases in the R&D-project "The KUNNE workplace", explores the relationship between the *business' goals* (and ambitions formulated by the organisation's management), the briefing process (end-user participation, and formulations of needs and intentions), and the final design. It focuses on the *translation* from business needs, stated in a business language, into briefing, and different ways to describe user requirements in order to aid the later translation by the architect into design. We will explore the different *boundary objects* which are used in this translation, as well as different techniques and *participatory processes* used in order to develop, understand, and describe user needs.

Keywords: Briefing, user participation, knowledge workplaces, communicating design

"WHAT DO YOU WANT YOUR OFFICES TO DO FOR YOU?"
The traditional Norwegian office building used to be inhabited by knowledge workers in individual cellular or combi-offices. During the 1990s, new trends and new office solutions challenged that norm, and faced organisations with questions of how more open space could be used strategically. They started to consider how their facilities are affecting their efficiency and effectiveness. In general there are at least two kinds of motivation to change space use and office solutions: space efficiency and cost reductions, and improved productivity, satisfaction and learning by innovative use of space. Earlier studies have shown that focusing on the possible strategic benefits to the organisation's value creation tends to increase the organisation's benefits from new office environments (Arge et al., 2000).

With more emphasis on the strategic value of the building project, more focus has to be given to briefing and the translation of needs to a physical solution. This paper describes experiences of briefing processes in the R&D-project "The KUNNE workplace", which is a 4 year project, financed by the participating companies as well as the Norwegian Research Council. In the project we study the relationship between space and use, combining knowledge from architecture, briefing, and facilities management with knowledge management and organisation development. The aim is to develop knowledge of knowledge workplace making; briefing, design, and use; and to research the relationship between knowledge work and the physical environment. The KUNNE project has used an action research methodology, and has carried out case studies together with the 7 participating organisations.

An important finding is that offices can be an important tool. In order to succeed, one must be able to translate the visions and objectives of the organisation, to understand its needs, and to challenge the organisation to state and redefine its assumptions of what space can do for it. Then this must be transformed into a brief and a design for new offices. In most of our case studies, the translation from needs to brief to design has proven to be the most difficult task. That is why we have decided to pay special attention to methods and tools which can serve as facilitators in the transformation process. In this paper, we have focused on the translation of the users' or organisations' needs to actual designs, and on tools to aid development and translation: Boundary objects. In our work we have applied an operational definition of boundary objects as objects, methods, and processes which can facilitate development of user needs (the process of briefing), and aid the translation of the brief into architectural designs by engaging different actors in different parts of the process.

THE BRIEFING AND DESIGN PROCESSES

In the traditional picture of the building process, and thus also the briefing, one development phase has to be completed before entering the next phase. In early planning there is a tradition for developing and discussing the needs of the stakeholders/users, and to summarize this in a written document: the brief. Most architectural competitions are based on this understanding of the process. In other cases, the awareness, formulation, and statements of needs are parts of an iterative process, which cannot be separated from the organisational development and context, or from the architect's growing understanding of the problems the design will answer to.

> "Design and briefing are integral parts of the same process with much of briefing carried through the process of design. During this process the language used by the organisation is translated into the language of building" (Blyth et al., 2001, page 21).

In order to understand the client's and the user's needs and wants, briefing is a process in which all factors related and connected to the organisation's visions and goals are purposely compared. The process is an 'iterative, reflective and interactive process', where ideas are tried out, rejected or adapted, or gradually developed and detailed (Blyth et al., 2001). In the process, within several participants involved, and hence dissimilar expectations which must be managed, communication depends on the interaction and cooperation between them, as well as how information is structured and managed (Blyth et al., 2001).

To ensure success in briefing, some complications must be avoided. A crucial factor often revealed in building projects is that the decisions are taken on unexpressed, diffuse, or unexperienced visions about the organisation's future. If the input to the design team is deliberately vague and ambiguous, it can deceive the designers and conceal the organisation's real intentions, just as the suggestions from the design team can make the organisation and the users confused by not matching their expectations. This can result in an iterative process that ends with a less than optimal solution. Hence, a wide and highly effective system of communication is important when briefing (Blyth et al., 2001).

Like the briefing process the ‘design process is iterative, reflective and interactive’ (Liedtka, 2000). In their book *Managing the Brief*, Blyth and Worthington describe the design process as ‘a process of argumentation and experimentation’, in which the design team has shared information and discussed ideas and several topics for a considerable time, by ‘using sketches, photographs, models, literature’ and sometimes excursion to buildings ‘as a means of communication’ (Blyth et al., 2001). Donald Schön describes the process as ‘a “shaping process” in which the situation talks back continually and each move is a local experiment’ caused by the trial of the redrawn problem, ‘as series of “what if” hypotheses, selecting the most promising one for further inquiry to a more evaluative “if then” sequence’ (Schön et al., 1994). Even if design is a very ‘complex and sophisticated skill’, in which the majority must be trained and practised, design thinking is a knowledge which can be considered, attended, and developed as ‘playing a sport’ (Lawson, 1997). This understanding of the building- and briefing process poses new challenges for architects and designers. As Duffy and Hutton describe in their book *Architectural Knowledge*, architecture is a ‘practical, project-based and site-specific discipline’, in which problem solving is a cycle of planning, doing, checking, and action, which makes it ‘open-ended and systemic’. Architects are naturally ‘idea-hungry and solution-orientated’, anticipated to be capable to connect and reformulate in design, ‘both practical and cultural’ (Duffy et al., 1998). But they are also under ‘social pressure to be creative’, by feeling induced to an expected diversity in methods or solutions in every new project (Peña, 1987). In his analysis, Donald Schön assumed that competent practitioners as architects, engineers, planners, managers, ‘usually know more than they can say’, which means they hold a tacit knowledge, an intuitive knowledge which makes it possible to exercise ‘reflection-in-action’ in the briefing process (Schön, 1995). In order to meet the challenges posed by the strategic perspective on workplace design, architects have to develop their design based on a deeper understanding of the organisation and its needs. We argue that by being more aware of the importance of translation of information and understanding from one stakeholder and one context to the next, and by developing new tools to facilitate discussions to aid these critical translations, architects may be able to design workplaces that better answer to the organisation’s needs.

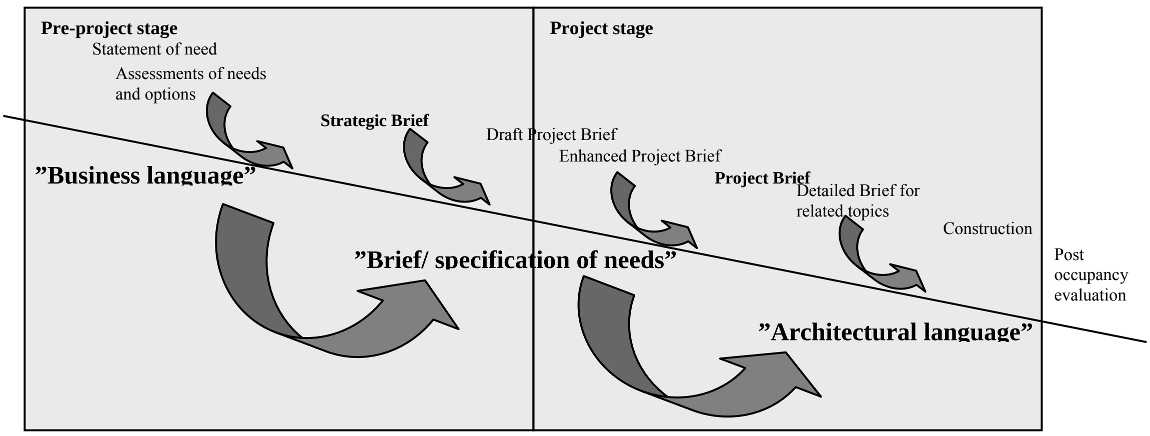


Figure 1. Translations and the stages in the iterative briefing process (Illustration stages based on the work of A. Blyth and J. Worthington (2001)).

LANGUAGES AND TRANSLATION IN BRIEFING AND DESIGN

Briefing and design processes are iterative and creative processes of suggesting and developing ideas and plans, in order to find more appropriate solutions. The effect of learning from experience through these processes, gives a better achievement. In this picture, it is important that the information supplied is neither more, nor less, but exactly as much is needed, to fulfil each of the participants' duty, structured as **'who** should give and receive **what** information and **when**'. The processes demand a 'horizontal communication' (Blyth et al., 2001) or a mixed mutual and common language, described as multilingual (Sørensen, 2002). Schön claims that 'a transformation is demanded, within a framework of accountability', where the designers manage to facilitate the dialogue with the client performed as a 'reflective conversation'. Methodically using perception, comprehension and representation (Schön, 1995), the designers will produce more insightful solutions.

In most office innovation literature the importance of defining the contents of workplace terminology is stressed. In *The Office. The whole office and nothing but the office*, the authors claim that a common language is indispensable, owing to the fact that the organizations market their ideas and concepts by creating their own terminology (Vos et al., 1997). Employing "team-work" and "collaboration" as collective terms for every interaction with other people, prevents designers from using them as precise terms that result in more precise responses as they design spaces to support group activities. Designers can serve clients well by first defining these terms in specific ways that help them to understand their real aims (Myerson et al., 1999). In the research project "The KUNNE workplace" (KWP), a typology of workplaces is used as a tool to aid communication when defining and designing knowledge workplaces (Gjersvik et al., 2004). Defining terms and creating a common terminology can be used as one type of boundary object.

BOUNDARY OBJECTS

In the building process, there is a development from the business language of the organisation to spatial requirements (sometimes defined in written text - the brief) and into architectural design. In the constructing process, the architectural design is translated to the constructor's language, and thus transformed and translated into a physical artefact. In all these transformations there is a translation, which is facilitated by using different kinds of boundary objects.

We have used the term *boundary objects* to gain new methodological insight to the process of briefing and design, by connecting to theory developed in knowledge management. In the KUNNE project the term "boundary objects" has been used in order to describe 'objects that become shared foci for the attention and explorative activities of people with initially different interests, expertise and language' (Carlsen et al., 2004, p. 229). The importance of the "half-worked" nature of the objects has been highlighted, allowing participation in development and construction of the boundary object. The building in use, and the organisation using a building, can also use boundary objects in order to evaluate, improve, and learn. Different kinds of boundary objects can thus be used in different phases in the building process, see figure 2.

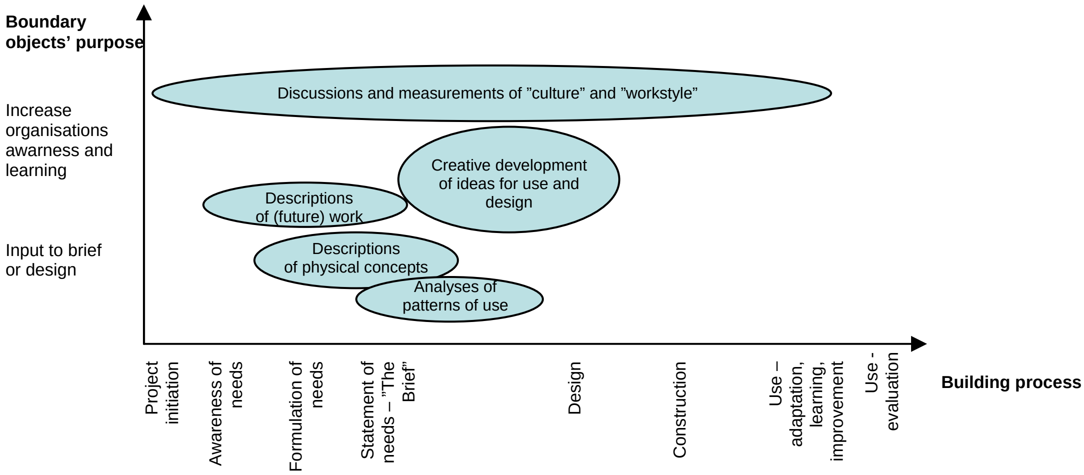


Figure 2. Examples of boundary objects used in briefing and design.

EXAMPLES OF USE OF BOUNDARY OBJECTS AND TRANSLATIONS

In KUNNE researchers have facilitated several briefing processes with different stakeholders involved, and developed different tools and methods in order to facilitate the development of awareness, understanding, and new solutions. The illustration shows some of the boundary objects we have been working with. The different boundary objects have been used in real cases with different organisations. The research has been action based, involving researchers both in the development of the projects and in evaluations and analysis. An open general framework has been used to be able to compare the different case-studies. In the following text, we describe some of the boundary objects which are developed to aid translation from awareness of needs to workplace in use.

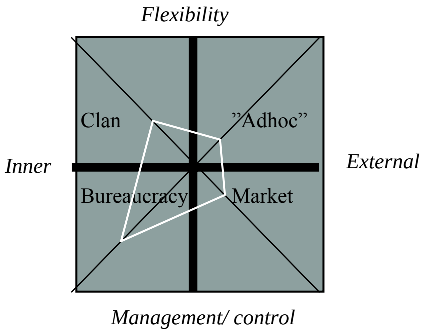
Example 1: Statement of vision and goals

In all projects, the business' strategic management was involved in the process. Formulation of the business' objectives by new offices in a new building, or by remodelling existing offices, were discussed and connected to ongoing strategic processes. We found this to be one of the most important phases in the project. It forces the organisation's management team into a discussion of what they want their new workplaces to be. In our experience (Blakstad et. al., 2003a, 2003b, 2004), many managers are not aware of the strategic possibilities in developing new workplaces. A common process, deciding what the main goals should be, should ensure involvement and commitment from top management. It is also important to prioritize between possible and conflicting goals. The output of these strategic discussions, including statements of visions and goals, has been used in the later phases of the project. The process ending with a statement of strategic visions and goals has been the most important means to communicate the main objectives to all actors in the process.

In one project, the main goal developed by the management team was: *"Enhance learning, sharing of knowledge and collaboration in production of knowledge"*. The main goal was specified into general directions for the type of space and technology they wanted, e.g: "Open space workplaces for all employees, including top management". The statement of vision and goals was communicated to all employees, designers, and major decision makers. When we later evaluated the new office environment, enhanced learning and co-operation were the two most significant improvements (Gjersvik et al., 2005). Other projects have taught us that success is probably not solely due to the quality of the vision statement, but due to the fact that the top management and project management used the statement actively to create a common understanding of what they where trying to achieve. The vision statement served as a boundary object, created by the management team, but later discussed and understood in different phases of the project and between different stakeholders.

Example 2: To increase the user's awareness and learning
The comprehension of the organisation's context, visions and goals, needs and resources, is often rather vague. The awareness of different types of work, organisational and external challenges and possibilities, must be heightened in order to take advantage of the possibilities related to designing new workplaces. In KUNNE, we have developed different techniques for facilitating discussions to increase awareness and learning of individuals, groups and the entire organisation's needs and use of space. The aim is to develop greater consciousness, for use in discussions in briefing and participation processes. In one case, different kinds of boundary objects were used to facilitate these discussions:

- Taking the pulse – the organisation's culture
  Based on a short questionnaire, we developed a profile with two dimensions (flexibility – control and level of bureaucracy). The profile represents the organisation's present culture, and is used to facilitate discussions about how the culture could be developed into the new situation.
- Taking the pulse – the organisation's work types
  A short questionnaire produces a profile along the same dimensions as used by Duffy (Duffy, 1997). The relation between the rate of interaction or autonomy and rate of individual or collective processes produces a picture of the present situation. Again, this is used to facilitate a discussion of what the organisation would like this to develop into.



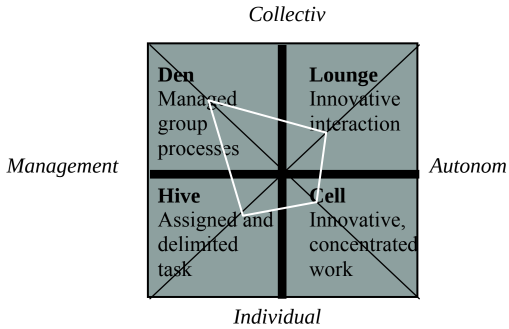


Figure 3. Diagrams of "Culture" and "Work types". (Both methods and diagrams based on the work of M. Hatling and T. Paulsen, SINTEF. From the KUNNE workplace project.)

The purpose of these processes was to open up the users' minds, to help them understand their work activities, their needs, challenges, or possibilities, as well as to understand their organisation's culture. The researchers participated as facilitators, helping the organisation to learn and to express their needs. The researchers assisted them through their discussions. With metaphors and symbols, the users managed to see the opportunities of changing the physical environment, and were able to ask the substantial questions about who they are, and who they should be as workers in the organisation.

Example 3: Descriptions of (future) work
In most cases, space is only one of several supporting mechanisms at the workplace. Information and communication systems, management and leadership, services and other supportive functions will, together with space, define the physical environment in which knowledge work is performed. In many of the KUNNE projects we have used workshops to develop a typology of knowledge work in that particular organisation. The underlying assumption is that different kinds of knowledge work require different work settings.
To each work type, the effect of the physical environment was studied. Some of the typologies in different projects are (Gjersvik et al., 2004): System-based customer support, Project development, Management, Complex problem solving in teams, "Deep diving", individual concentration and "Snorkling", individual concentration.

We have often used the work typologies together with the next example of boundary objects: descriptions of physical concepts. It is crucial that the architect takes an active part in these discussions in order to understand the implications for the final design. The descriptions of work are worthless if they are not followed by a design that answers to some of the challenges discussed in the process.

Example 4: Descriptions of physical concepts
Another assumption in KUNNE, is that organisations should focus on what they "want their space to do for them". This will better facilitate a process that leads to solutions that fulfil the underlying objectives compared to a discussion starting with the users "what should the workspace look like". This has resulted in a workplace typology based on function (Gjersvik et al., 2004):

- Space for learning, communication and co-ordination in projects: Project rooms of different sizes and shapes. Enclosed, shared team space with individual, temporary workplaces.
- Space for change: Flexible size and furniture in order to rearrange project rooms as projects and teams change.
- Space for creativity and communication: "Process rooms" for active, team-based work and discussions. Enclosed space equipped with the necessary technology.
- Space for concentration: Some cellular offices for people with special functions, "library", quiet space for people with their workplace in project rooms.
- Space for bringing the right people together: Includes external consultants in teams – workplaces for guests in project rooms.

We have also developed "catalogues" of different functions and the spatial requirements related to them. The workplace typologies form the basis for these guidelines, intended for use by different organisations in planning of new workplaces.

Example 5: Creative development of ideas for use and design
As a result of the lessons described above, we have experimented with other kinds of processes in order to prepare the organisation for new workspace and to make them aware of the possibilities they are facing. In one case, a new office for architects/researchers, some of them researchers in the KUNNE projects, we were both users and designers in a participatory process to change our own office. A schematic space plan was developed based on the experiences with office innovations and research. The main goal was to enhance co-operation and to show a distinctive identity. It was decided that the collective space should be prioritised on the expense of individual space. It was also decided that we should reuse most of the furniture and equipment, both to keep cost down, but also to reuse resources for environmental reasons.

As a method during the briefing processes, a creative process was arranged as a day-long workshop directed by Oasen, a "physical-surroundings lab" at the Norwegian University of Science and Technology (http://www.idefondet.ntnu.no/oasen.htm). Different methods were used, encouraging people to write, draw and build metaphorical models to develop and test ideas collectively. Different tools and boundary objects were used together, as translation from the users' ideas, needs and dreams both as individuals and as part of the same team. Some of the tools used in the creative process were: metaphors, e.g. illustrations and words, toys, e.g. animals, stickers to write words and thoughts on, paper, e.g. a paper reel, colour-pencils and crayons, and strips of different kind of cloth.

DISCUSSION

In this paper we have focused on the translation of user needs to knowledge workplace design. We have based the translation between the pre-project stage and the project stage on a commonly used (at least theoretically) understanding of the building process as an iterative process. The iterative process ranges from formulation of needs, requirement and constraints from strategy to project and detailed brief in workplace planning and design. Based on previous work developing typologies for workplace design (Gjersvik et al., 2003) , and description of physical concepts, we have based our case-studies on the boundary objects developed in the KUNNE project. The boundary objects are 'objects that become shared foci for the attention and explorative activities of people with initially different interests, expertise and language' (Carlsen et al., 2004, p. 229). Our findings in several action research-based case-studies, show that a better translation of user needs is attained by the use of boundary objects as:

- Discussions and measurements of "culture" and "work-style"
- Descriptions of (future) work
- Descriptions of physical concepts
- Analyses of patterns of use
- Creative development of ideas for use and design

From our experiences with using boundary objects in the KUNNE project, we have learned that it increases the user's awareness and knowledge of themselves. Using boundary objects in the project helps the user to better understand the work types and their distinctive character, and creates a better environment in which different actors work and co-operate. Finally, boundary objects makes the translation to environmental design/architecture easier.

A well-described set of work types and required functions will not automatically ensure that you get a design that fit your descriptions. The translation may not be performed correctly. This may be due to the fact that the architects' problem solving is triggered by other types of information, and that describing too much in detail may be counterproductive. One way to avoid this problem is that the architect or designer takes part in developing the solutions – which means that you do not separate the development of descriptions and the first development of spatial concepts. The purpose of briefing may also be development of the organisations' awareness in order to make them demanding and productive clients. This will usually also make them able to use the new environments to their advantage, because awareness of their use of space has been heightened. Tools to facilitate discussion and to enhance self-awareness and visions and goals are, in our experience, the most efficient and effective tools when working with the user organisation.

Acknowledgements

We would like to thank the Norwegian Research Council, which made this work possible through financial support to the "KUNNE program", and the KUNNE project for the experiences from different projects, which we could develop and evaluate. We have learned some vital lessons that will be addressed in further work in KUNNE and in a doctoral study at NTNU/SINTEF.

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KNOWLEDGE DESIGN. CONSIDERATIONS FOR CLIENTS WHEN CHOOSING BETWEEN SYSTEM SUPPLIES AND UNIQUE DESIGN

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Abstract
In order to boost innovation in a construction industry stuck in traditional patterns of cooperation, politicians and researchers have lately been promoting emergent new production structures, focusing especially on the cooperation between producers of building components. A recent Danish report on the issue[1] introduces two new key agents called ´concept owners´ and ´system suppliers´ and in the present paper the meaning and implications of these terms are briefly described. One major advantage expected from a renewed structure, is a better handling of knowledge that will increase the producers´ ability to create innovative solutions. But in order to understand and demand new innovative solutions, also clients and advisers must understand, accept and adjust to this new structure of knowledge creation. On a structural level there must be coherence between the ways knowledge is handled by all agents, in order to arrive at a successful construction project. To investigate the possible existence of such coherence, this paper tries to map the handling of knowledge by three major types of clients and three major types of producers, in the initial phases of a construction project. To analyse the processing of data and the resulting creation of knowledge, the knowledge theories of Max H. Boisot are introduced. The analysis suggests that there is a clear coherence in the type of knowledge being processed by specific types of clients, and the knowledge being processed by specific types of producers. The importance of making a clear distinction between operating with highly abstract knowledge or more concrete and context bound knowledge is emphasized. Still, an extensive oscillation between these two forms of knowledge is often demanded. This can be done in a well-documented and controlled way by for instance a system supplier, but sometimes in a faster yet less transparent way by skilled advisers. Before starting a construction project a client should therefore consider, whether a process based on system supplies or a process guided by a traditional adviser, will match his own knowledge processing structure better, in order to create a common project of optimal value.

Keywords: Briefing, concept owner, innovation, knowledge, system supply, value.

SHORTCOMINGS OF THE DANISH CONSTRUCTION INDUSTRY
The Danish construction industry has lately been criticized by Danish politicians and researchers for being too expensive and for lacking innovative initiatives. Inadequate price competition on building materials, absence of investments in research for new products and construction systems, and an inefficient handling of the building process are problems that have been emphasized by the critics. One of the often mentioned reasons for waste and the low degree of technical innovation is, that most building projects are starting from scratch, involving each time a new combination of consultants, contractors, suppliers and sub-suppliers. In this way a continuous sharing of knowledge over more projects between many agents does not take place. As a response to this researchers have

[1] Mikkelsen et al (2005)

been looking for new approaches to especially the production and installation of building components. In this effort it has been crucial to find an approach that could assure an extended exchange of knowledge between numerable agents, occupying different parts of the production chain.

DANISH REPORT ON SYSTEM SUPPLIES

Researchers from the Danish Technical University, Aalborg University Centre and the Danish schools of architecture in Aarhus and Copenhagen have been involved with this work and have recently presented a report called " System supplies in the building Industry".[2] Taking inspiration from the production industry, the scope, as described in the report, is to establish long term cooperation between ranges of producers, combine their products in integrated systems and offer these ´system supplies´ to clients as a complete package including production, installation, service and total product liability. To obtain the maximum advantage from this way of organising the production and installation of building components, the general structure of the construction industry should preferably be modified. Planning, production and installation should be concentrated in fewer and larger entities. If system supplies are well configured, and have a well defined interface that is compatible with other systems, the most efficient use of system supplies will be in concepts that are predestined for integrating a number of these. New possibilities for mass customisation make up the most important difference between this strategy and large construction systems of earlier decades. It is emphasized though, that system supplies can also be implemented gradually as a supplement to unique design solutions in projects designed traditionally by advisers, as it is already seen with i.e. prefab bathroom units.[3] The report[4] is suggesting that the coming key players and their potential assets in a new structure based on system supplies could be the following:

Clients:

Developers, investors or end users, who initiate a construction project.
Assisted by consultants they formulate a brief describing needs and specifications for the coming project and start looking for an appropriate concept.

Potential assets:
Better access to:
More flexible solutions (changeable over time)
Innovative technology
Purchase of projects at a lower price
Total product liability and less suppliers

Advisers:

Architects, engineers etc who work independently or are employed with clients, concept owners or system suppliers.
Potential assets:
An extensive use of pre-designed concepts and system supplies will leave less space for creative and unique solutions in the individual project as the primary task will be

[2] Mikkelsen et al (2005)
[3] EJ Badekabiner, described in: Mikkelsen et al (2005) P. 79
[4] Mikkelsen et al (2005)

configuration instead of designing. A whole range of design decisions will be made by system suppliers and concept owners, leaving the project advisers with mere specification and controller functions, and maybe with the task of analysing possible customized adjustments of the concept to the particular site and the special needs of the particular client. Yet advisers will also need to be engaged by concept owners and system suppliers to develop, design and customize concepts, systems and products. This can be seen as a new and emerging field for architects and engineers.

Concept owners:
Architects, developers or contractors who have developed one or more general concepts for an entire building typology.
The concepts are prepared for the implementation of a wide range of compatible and well configured system supplies and standard systems can be combined with unique design solutions. The concept owner offers product liability for the concept as a whole.

Potential assets:
A better opportunity to:
Configure new projects in a fast way.
Offer concept liability based on predictable and well tested systemic solutions.

System suppliers:
Can consist of a lead company with sub-suppliers or a group of companies in strategic partnering. Together they can control parts of, or the entire production and installation chain, for their specific system. The system supplier assures the internal functionality of the system and the external compatibility with other systems and concepts. Systems can be subject to mass customisation according to wishes from clients, concept owners or advisers. The system supplier offers total product liability for the system.

Potential assets:
A better opportunity to:
Collect and control data and feed back from activities along all parts of the value chain in current and former projects.
Do systematic research and develop intelligent integrated solutions
Offer mass customisation of system solutions with no extra costs
Produce larger units in a controlled environment (factory instead of building site)
Produce systems and components at a lower price

Suppliers (producers):
Companies that act as sub-suppliers for the system supplier.

Summarizing, the universal potential asset of system supplies and its accompanying phenomena in the construction sector, can be seen as the possibility of establishing a new and better facilitation of the creation and handling of knowledge. I will therefore attempt to investigate the flow of knowledge within and between the key players of the new structure suggested above, focusing mainly on the creation of knowledge within the organisation of the client and between the client and the concept owners / system suppliers. This investigation implies a theoretical approach to the handling of knowledge.

How can knowledge be created and described, and how can it be transformed into assets and value, within the premises of knowledge society.

INFORMATION SPACE

In his book “Knowledge Assets” Max Boisot attempts to map the different transformational states that information can go through, as an act of data processing is being conducted. His underlying presumption is that: “any system, whether social, biological or purely physical… will act to minimize entropy generated by (data processing) activities”. In other words we try to structure the data that we are dealing with in order to economize our work and create value. This structuring of data is basically being processed according to two techniques: Codification and abstraction.

The acts of codification and abstraction are able to transform knowledge from ´tacit´ personal knowledge to ´explicit´ impersonal knowledge that can be shared.[5] Codification can be described as the act of assigning phenomena to categories. By coding data we establish an ordered distinction between them based on their immanent properties. The schemes that we use to classify data can operate with categories that are perceptual (as when sorting oranges according to colour and weight) or conceptual (as when sorting oranges according to country of origin).

Once we have established an idea of possible categories that can structure the data we are dealing with, we can start to consider which of these categories are likely to be most relevant for the purpose of our data processing. This second technique for minimizing the amount of data is described by Boisot as abstraction. Abstraction is often based on some experience about cause and effect, which enables the conductor of abstraction to select categories that are likely to make the processed data more obviously relevant to a broader group of agents.

Making knowledge explicit and structured is a good foundation for sharing it with a larger audience. Still, we need a scale to measure the availability of the knowledge to those who wants to use it. To describe this third factor in the processing of data, Boisot introduces the notion of diffusion. If data is technically and culturally accessible it is diffused, and if it is kept within a closed circle it is undiffused. Boisot states that the more data can be abstracted and codified the higher its potential for diffusion and thereby its potential value. To describe the different regions that knowledge can inhabit Boisot constructs what he calls the Information space. It is constituted by a diffusion scale as the x-axis, an abstraction scale as the y-axis and a codification scale as the z-axis:

[5] Nonaka and Takeuchi (1995)

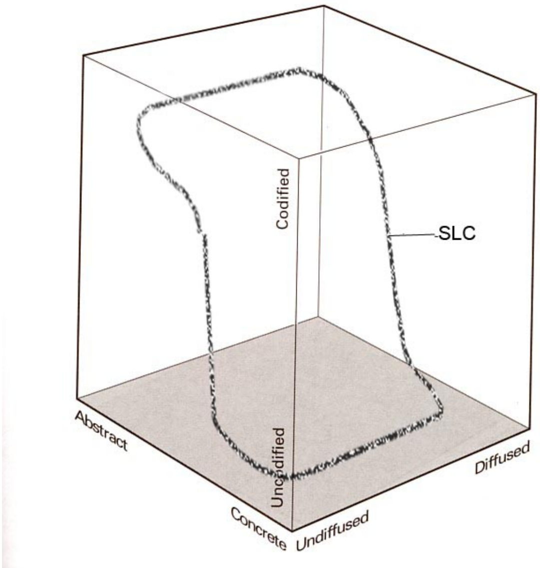

Fig. 1.Representation of Boisot´s Information Space

Boisot suggests that information, as it is being processed, is travelling through this space following what he calls a Social Learning Cycle (SLC). The form of this SLC can vary according to the process being conducted, and the organizational and industrial setting that is dominating the process. It is the essential idea in Boisot´s theory that the precondition for innovation and the creation of value and knowledge assets in a company or an organization is that knowledge is moved through all regions along the SLC.
Boisot names 4 ´frames´ for information transactions that are prevalent in the 4 outer corners of the I-space:[6] Bureaucracies, markets, clans and fiefs. In accordance with Herlau and Tetzschner [7] we choose to draw these and the activities from fig. 1 in the following 2-dimensional representation of the I-space that will later come to use in the mapping of knowledge creating transactions by different types of clients.
We can know describe some basic states of the data flow along a SLC in I-space:

[6] Boisot(1998), p. 126 – 127.
[7] Herlau and Tetzschner(2004), p. 94

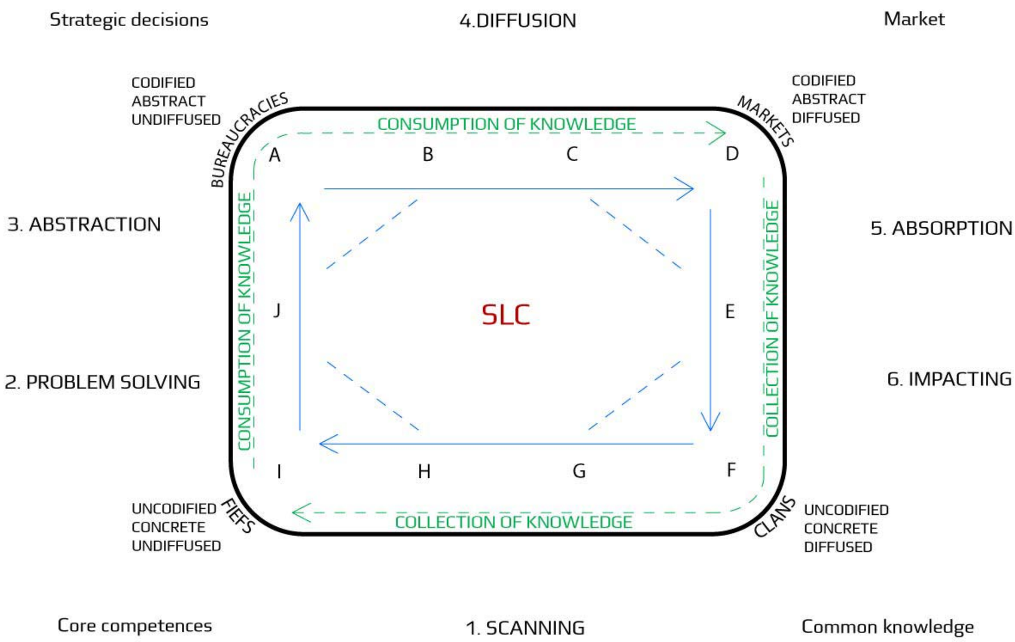

Fig. 2. 2 dimensional representation of I-space

1. Scanning. Performing a scanning we look at generally accessible concrete knowledge and extract a more personal selection of knowledge from it.
2. Problem solving. We start to structure and codify our personal tacit knowledge.
3. Abstraction. We start to look for more general applications of the structured knowledge.
4. Diffusion. The codified and abstract data can now be shared with a larger group of agents.
5. Absorption. Data is decoded by presenting them in a specific context.
6. Impacting. The abstract principles of the data are translated into a specific practice. (artefact, rule, behavioural pattern)

This description is schematic and some steps such as problem solving and abstraction often run concurrently.

KNOWLEDGE ASSETS OF THE CLIENT

Regarding system supplies, researchers have until now emphasised the obvious advantages of the flow and creation of knowledge inside the organisation of the system supplier. But the handling of knowledge by clients seems to be just as important. Using the understanding of knowledge as introduced by Boisot, I will in the following pages try to map how data might be processed by clients in the initial phases of construction projects. Initially, it is important to notice the structural and intentional complexity that the term client implies. Traditionally projects are initiated directly by a client who forwards the project to ensure a suitable frame for his own future functional needs and aesthetic preferences. But the client may in some cases have very loose relations to the actual end-users of the project, and his interest in the project may have a very short time limit.

To analyse different procedures in the handling of knowledge, we will here work with the following three main categories of clients:

1- The client with short term interests in the construction project. (Short term client, STC) This type of client is typically a developer or contractor who initiates, develops and builds a project with the dominating objective of selling it to make money.
He is very often an experienced, professional and frequent builder.
2- The client with long term interests in the construction project (Long term client, LTC) Typically an institutional investor or a public client who engages in a project with the objective of investing capital in real estate or providing facilities for a public function. He is often an experienced client, frequently involved with construction processes.
3-The actual end-users. (User)
Being or representing the people whose functional and aesthetical needs should be met by the construction project. He is infrequently involved with construction processes.

These types of clients can, due to their different objectives and positions in the construction landscape, be expected to have quite different ways of handling knowledge.

On a structural level, one important difference is the amount of experience with construction processes that a client has. Blyth and Worthington[8] are noting, that clients who build frequently and for universal use, tend to work out briefs that are detailed, prescriptive, based on past experience (i.e. post occupancy evaluation[9]) and aiming at standard solutions. On the other hand clients who build infrequently or for more specialised use tend to make briefs that are more open and identifying only the performance expected.[10] They have little former experiences to build on, and they need external advisers to investigate their needs and ensure that these needs are transformed into suitable solutions. Seen this way the frequent builders (STC s and partly LTCs) can be expected to handle a lot of knowledge internally in the initial phases whereas infrequent builders (Users) need more advise and external exchange of knowledge.
To underline the potential complexity of data processing in the initial phases of a construction project it can be mentioned that all three types of clients may be present simultaneously, as when a developer builds a house, that has already been sold to an institutional investor, who has already rented it out on a long term contract to a user. On top of this, the surrounding society, authorities etc. will also blend in with demands and wishes and thus contribute to a very complex pattern of knowledge exchange.

ANALYSIS OF THE PROCESSING OF KNOWLEDGE

In the following we will attempt to analyse how the 3 different types of clients can be expected to process knowledge, in the initial phases of a construction project in order to meet their objectives. We will also see how this corresponds with the handling of knowledge by system suppliers, concept owners and producers, and how advisers can assist the client in these phases.

[8] Blyth and Worthington (2001), p. 64-65
[9] Blyth and Worthington (2001), p. 82
[10] Blyth and Worthington (2001), p. 64-65

1 – The short term client

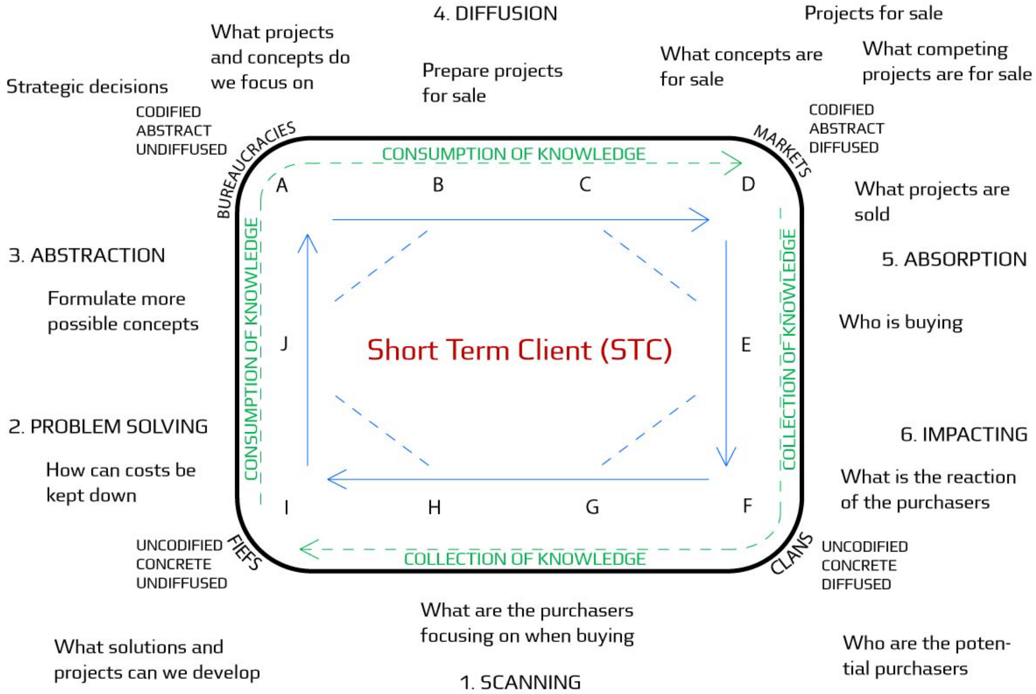

Fig. 3

The general impression from fig. 3 is, that the short term client (STC) is generating knowledge primarily about the market. This implies both the condition of the market and how he can approach the market. Unless he already has a contact to a purchaser with more special needs, he must focus on solutions that are generally demanded on the market, and the question of price is obviously an important key aspect here. The STC is not so interested in the deeper needs of the user, but how these needs are represented universally on the market. Seen from an SLC perspective, he is performing a high and flat SLC in the I-space, processing information that is highly codified and abstract, and creating knowledge value through his ability to move frequently in fast learning cycles on this level. As he is focused on projects that have a general applicability he will possibly also be searching for concepts and solutions with a good universal reputation and a well documented functionality. In this way concept owners or system suppliers could be the perfect match for him, if they are cheap, and able to document a favourable attitude towards their system on the market. This match can be reinforced if potential purchasers of the project, have a general interest in other of the key assets of system supplies such as flexibility, product liability etc. The advisers a STC will need in this situation are primarily real estate consultants who are professional in scanning the market, and advisers who can spot the right concept and the right system supplies, in order to compose a low cost project that can be sold at a high price.

2 – The long term client

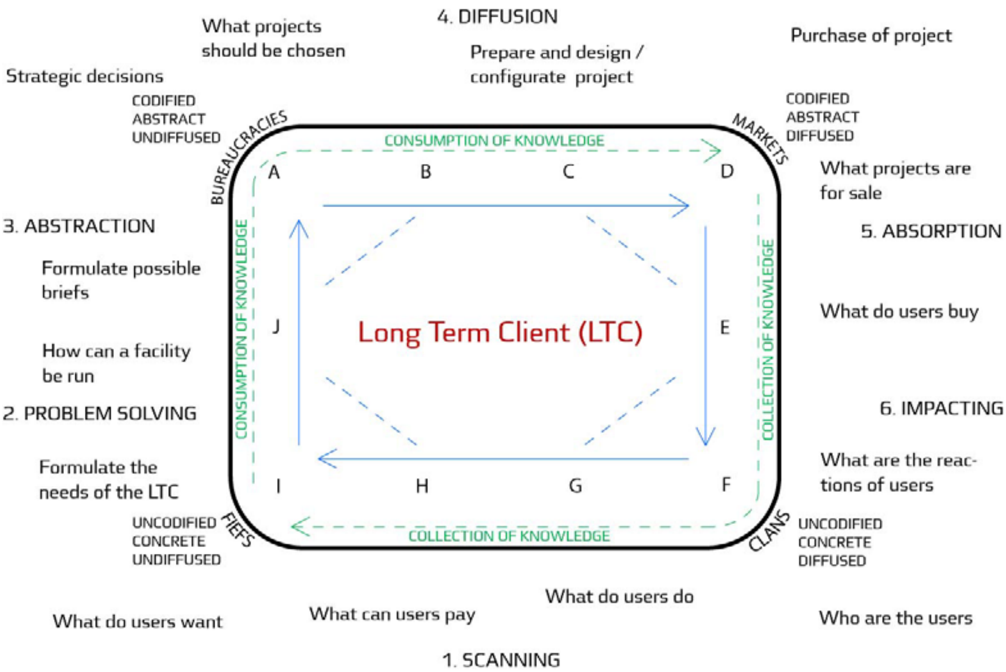

Fig. 4

The Long Term Client (LTC) is in a more complex situation. Just as the STC he must be concerned with the acquisition price of the project. But where as the STC can create his profit by understanding the market at the moment of construction, the LTC must predict how his facility can be run profitably in a number of years to come. To anticipate unforeseen dynamic changes he has to know more about the users, their behaviour and preferences. He must continually be able to give the users a reasonable amount of what they want, so they do not desert him. At the same time he must plan the costs of operating the facility over a time span, and therefore have a notion of facilities management.
For the LTC, the system supplier's ability, to deliver flexible solutions that can be changed over time, must be appealing as a possible lifeline, if his predictions about user preferences should fail. The only paradox is that flexibility often stands in opposition to conciseness, and the LTC may be forced to offer concise facilities to match the demanding users. To ease the facility management, the option of dealing with only a few system suppliers with total product liability and the potential application of new technology, must also be an important asset for the LTC. On the other hand the LTC is not necessarily focusing too much on the potential low cost of a system supply, as the long term perspectives of running the facility and attracting users are more important.
As the LTC is concerned with both user wishes, his own (tacit) knowledge of facilities management and codified and abstract concepts for buildings, he is performing a deeper SLC in I-space than the STC. He is creating knowledge assets by translating specific common user knowledge into highly abstract knowledge about constructions. This knowledge is again absorbed through the use of his facilities, and the learning cycle is repeated and continuing for years. For this process the LTC needs advisers who can help him identify (future) user wishes, formulate a brief, design flexible or concise facilities

that can meet these wishes, and help him choose, integrate and customize systems and concepts that are adequate for his objectives.

3 - The users

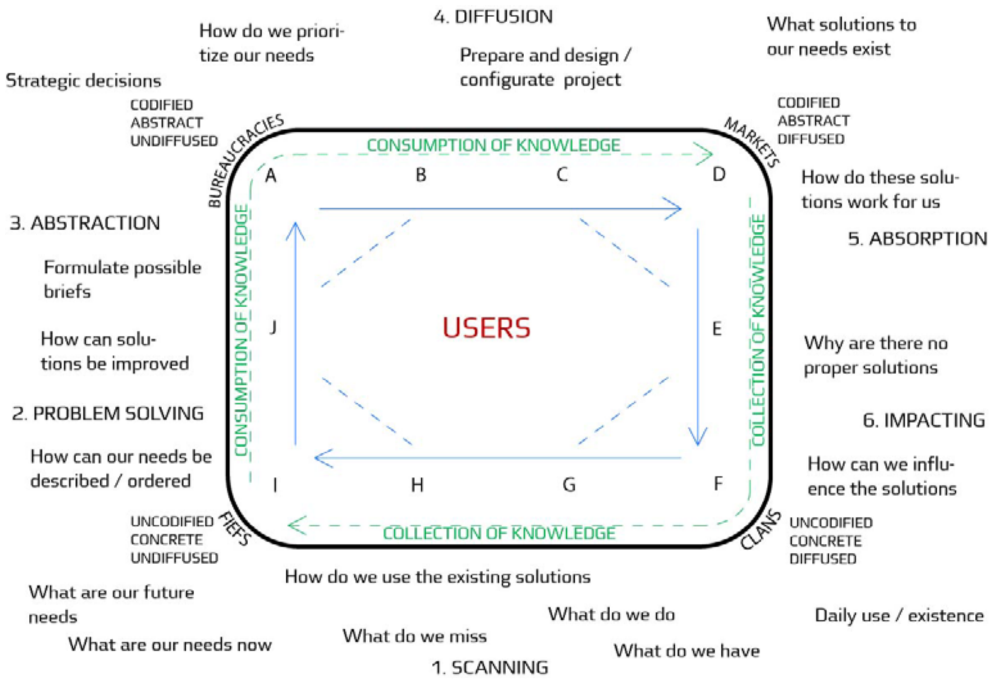

Fig. 5

Users see the world from a different perspective than an STC and an LTC. They are moving around in the more specific zones of the I space, preoccupied with their personal needs and aspirations and the potential solutions they can imagine. Although they may have visions for a large project in its entirety, their core competence is the detection of the specific needs, (a deeper phenomenon than wishes) whose fulfilment are important for their well being and ability to function in a meaningful way. Immersed as they are in their daily practice they may find it difficult to formulate their needs, envision their needs develop dynamically in the future and especially foresee the direction of this development. Frank Gehry has once stated that: “clients often don’t know what they want. And if clients do spell out what they want it usually turns out to be precisely what they already have.” [11] This statement can be taken further by saying that ´users do not know what they want until they see what they can get´. For this reason users only create knowledge value if they perform an entire cycle on the SLC in I-Space, as the actual formulation of their needs seldom gets going until they are confronted with possible solutions. But once users have realized what they want, they really want it, and not just a reasonable amount of it.

The possible solutions may be presented to the users in the form of system supplies or concepts, but as users are usually performing a low flat SLC in I-Space, staying on a relatively specific and un-codified level, the systems might be to abstract and codified for

[11] Weick, (2003)

them to relate to, unless they can be visualised or presented in a tangible way. ´Product liability´ and ´technical flexibility´ may be ignored in favour of the placement of the kitchen zinc. On the other hand users might really profit from low cost concepts and system supplies, making it possible for them to occupy facilities that would otherwise be out of reach.[12] The precondition for the access to low cost facilities is of course, that intermediary players (such as STCs and LTCs) do not cash in the money saved on production.(as they often do)[13] Users need assistance from advisers to realize and formulate their present and future needs, explain and visualize assets of unique designs, concepts and systems, and eventually assistance to formulate wishes for customisation of system supplies.

CLIENTS IN I-SPACE

The Social Learning Cycles of the different types of clients as described above can be visualized as shown in figure 6:

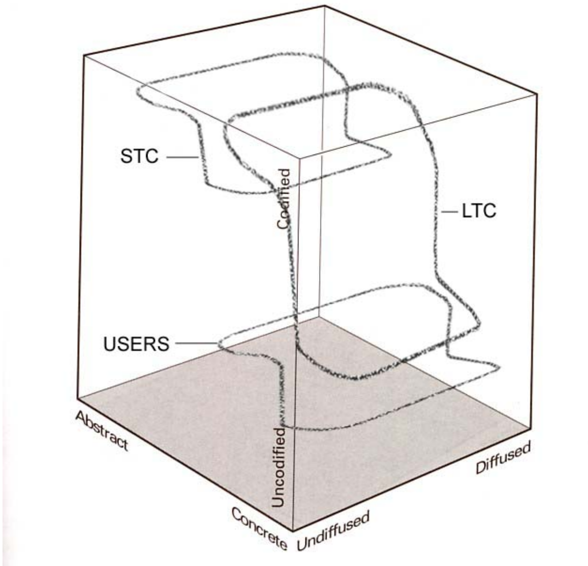

Fig. 6.

The STC is processing data in the top layers and the LTC is performing a span between the specific and context bound user layer and the codified and abstract conceptual layers. But the LTC is not immersed as deeply in personal tacit knowledge on the left side of I-Space as the users. The users are basically staying in the concrete layers whereas the advisers can be found anywhere within the shown sector of I-Space. In complex projects where STCs, LTCs and users are all present, the group of advisers must be composed so it can process data in the entire sector and thus create the necessary knowledge. Composing such a group and structuring the work, is a complex task in it self that should be investigated further.

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[12] I.E. the readymade housing concept ´Boklok´ by Skanska / Ikea, described in Mikkelsen et al,(2005)

[13] Professor Kristian Kreiner, Copenhagen Business School, was emphasising in a lecture at CINARK 2004, how prices on i.e. housing are mainly determined by demand and not by the production costs.

SYSTEM SUPPLIERS IN I-SPACE
Without having presented extensive considerations about the SLCs of concepts, system supplies and products as it has been done about clients, I succumb to the temptation of presenting an I-Space that illustrates my presumption of these SLCs:

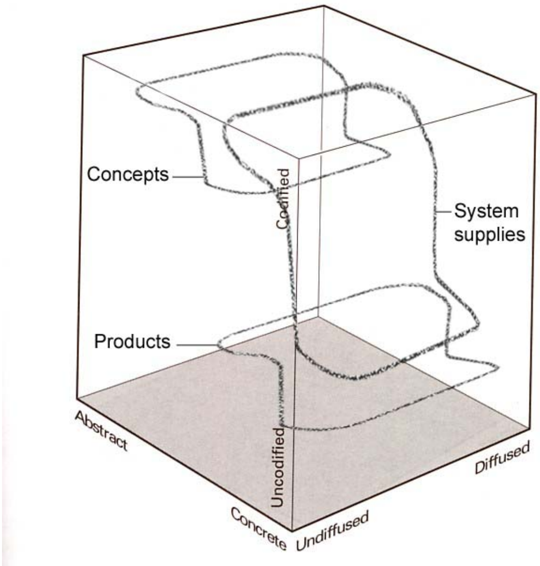

Fig 7.

Concepts are very abstract and codified phenomena that are the evaporated results of data processing on the more concrete levels. In the form they are presented and handled they stay in the top layers, taking in knowledge that is lifted up to these layers through the processing of data on lower levels. Concepts may for instance be composed by a series of system supplies that make the span between the more concrete layers where they find their product components and their validity among users, and the abstract layers where these ingredients as a whole can hit the market. Products can be highly codified and abstract but their absolute content of abstract knowledge will always be less than a complex concept, containing the accumulated knowledge of a lot of products and systems. On the other hand products are a lot more concrete and tangible than concepts. The wooden surface of a wall can be touched and admired, whereas its status as an ingredient in a prefabricated sandwich element (system supply) must be explained.
Now, as the attentive reader may have noticed a certain identity between fig. 6 and fig. 7 can be claimed. It might seem too obvious, and as there is no scale to the representation of the I-Space the actual data being processed is not identical in the two. But I might cautiously suggest, that the STC should focus his interests on concept owners, as the knowledge held by these has some of the same characteristics, as the knowledge he is creating by his own processing of highly abstract and codified data. In reality we actually already see STCs (developers) that act as a kind of system owners.[14]
In the same way the LTC should look to system suppliers as they represent the same span between concrete common knowledge and abstract building concepts as his own handling

[14] The STC company ´Sjælsø gruppen´ has initiated a concept where a whole housing quarter in the port of Copenhagen is constructed using the same construction concept, but with different architects designing (configuring) the particular buildings. (Sluseholmen, Copenhagen, 2005)

of knowledge does. The LTC can not just work with concepts because he needs more detailed and reliable knowledge about the (future) operation of his facility, user wishes and preferred solutions to these wishes.

Finally it comes as no surprise that users are concerned with products. It is the visible and tangible qualities of the surface of a wall, and not the way it was built, that matters to a user. The immediate appearance of products can be confronted with the tacit knowledge of the user. This does not mean that system supplies and concepts are of no importance to users, but it means that users are concerned with the functions and the interface of the ingredients of the systems, and not with inherent and hidden compositions and constructions. (As an exception to this can be mentioned concerns about for instance sustainability.) System supplies and concepts are the media for bringing the right spaces, surfaces and functions to the user. STC´s, LTC´s and their advisers are the agents who have the insight to evaluate and control these media.

CONCLUSIONS

As we have seen above, different kinds of clients can be supposed to handle knowledge in ways that are more or less parallel to what concept owners, system suppliers and producers do. Understanding the handling of knowledge by the client himself and each of the prevailing agents on the production side, will help the client establish a realistic idea of the potential value a given agent can be expected to add to his construction project. One of the big tasks of system supplies seems to be the ability to bridge the gap between abstract and concrete knowledge. To help establish this connection, Flyvbjerg[15] has introduced Aristotle's deed called ´phronesis´ as a principle for a simultaneous existence of abstract universal considerations and concrete context bound action. In contrast to Aristotle's other deeds ´techne´ (context dependant but connected to concrete knowledge about production), and ´episteme´ (context independent and connected to universal invariable knowledge), ´phronenis´ implies a synchronous harmony between universal values and concrete praxis.

In fig. 6 and 7 we have seen how short term clients and concept owners handle abstract knowledge with universal implications close to episteme in the top levels of the I-Space. In the bottom levels, users and product suppliers process concrete knowledge connected to ´techne´. System suppliers and long term clients establish a connection between the universal and the context bound. This does not necessarily happen simultaneously, but as an ongoing exchange between the two levels, between ´techne´ and ´episteme´. According to Flyvbjerg[16], the basic foundation for phronesis is the presence of experience. Experience is a precondition for the construction of valuable abstractions and allows for fast exchange between ideal and practical worlds. It is a key competence of for instance a skilled architect when he is acting as a ´reflecting practitioner.´[17] One of the main objectives by introducing system supplies, is to facilitate innovation by establishing such a systematic and continuous exchange of knowledge between different agents, some of them acting on different levels of abstraction. This oscillation between levels of

[15] Flyvbjerg (1991)
[16] Flyvbjerg (1991) p. 73
[17] Schoen (1983)

knowledge may be done by system suppliers in a careful and rational process that can be documented in detail.

A primary asset generated through this ordered transparency, is the possibility of sharing all knowledge with other agents and for instance conduct a smooth replacement of some components without destabilizing the whole. If lead times are short this facilitates changes at a late state of the planning, an option often asked for by clients. [18] But the presence of experience based phronesis in the work of a skilled adviser may also in some cases enable the immediate emergence of valuable solutions based on simultaneous considerations of universal and context bound factors. This process is just harder to split up and document.

In both situation accumulated abstract and concrete knowledge is at hand and can be transferred into new solutions. Different types of clients should consider some of the above mentioned questions in order to assess which agents and which project structures will perform this task better and thus create a maximum of client value in a specific project.

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[18] Blyth and Worthington (2001) p. 91

DESIGN MANAGEMENT

INTERNATIONAL BUILDING DESIGN MANAGEMENT: RESULTS FROM A CASE STUDY IN SÃO PAULO, BRAZIL

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Abstract
Economic, social and technological factors have encouraged the procurement of architecture, engineering and construction services on an international basis, and have lead to the establishment of remote design teams in recent years. The use of foreign consultants for complex building projects in developing countries can induce technology transfer and the adoption of innovative architectural and engineering design. However, in practice, it can also result in additional risks that, if not recognized and mitigated in the early stages of the project procurement process, can lead to difficulties during the design and construction stages. This paper explores the technological, managerial, organizational and cultural barriers that may arise from the assignment of international offices for the design of complex projects in developing countries. Analysis of a case study for a major project in Sao Paulo suggests that assigning foreign design offices for complex projects requires careful planning, innovative managerial approaches, appropriate communication and information technologies, attention to behavioural issues and mutual understanding of stakeholders' roles and responsibilities.

Keywords: Building design, construction, contracts, globalization, project management, quality.

OVERVIEW OF THE ECONOMIC AND POLITICAL SCENARIO IN BRAZIL

With a population close to 179 million people, a GDP around US$ 500 billion and a GDP per capita of 2800 dollars, Brazil has the largest domestic market in Latin America. Located in the Brazilian southeast, São Paulo is the country’s most important city with the 3rd biggest population in the world, behind Tokyo and Mexico City. In terms of the Brazilian construction industry, São Paulo is also the most important region for development, with about 5.7 million square meters of new buildings built annually. Despite its socio-economic importance, the construction industry has been traditionally considered as backward compared to other industries. Frequently, construction methods are poorly chosen, workers are not properly trained and on-site supervision and project management are lax. As a result, extensive waste, and project time and cost overruns are pretty well standard. The Brazilian construction industry also lacks consistent industrial policies, since its activity level is often erratic and driven by political motivations, such as absorbing non-skilled workers.

The Brazilian industry is dependent upon government programs such as low-income housing, infrastructure, and other civil works. High cost of capital, credit scarcity and public expenditure shortage have slowed down the construction economic activity in recent years, regardless of a housing shortfall in excess of 5 million units. The Brazilian construction industry experienced significant changes during the nineties. However, the roughly inconsistent economic growth in the past years may arguably affect the industry initiatives towards the improvement of its performance.

POTENTIAL BARRIERS FOR BUILDING DESIGN MANAGEMENT

In no other important industry is the design responsibility so detached from the production responsibility (Banwell Report, 1964). Harvey (1971) criticized the separation between designers and contractors in England and Saxon (1998) questioned the contractor's exclusion from the design process, seeing that designers are frequently expected to respond for elements that they do not fully understand. The construction industry presents a complex responsibility chain and nobody seems prepared to satisfy the client (Egan Report, 1998). Some commentators argue that designers could benefit from an early involvement of contractors, who are not usually involved before the tender process (Pocock *et al.*, 1997) under traditional procurement systems.

Frequently, designers and contractors are working together for the first time on a project. Even if the companies collaborated in the past, the assigned team member will be probably unknown to each other (Groák, 1992). The fact that project team members do not know each other in personal and organizational terms is not irrelevant (Brown, 2001).

The stakeholders commonly approach the project with particular expectations. Although these expectations vary according to the project type, clients usually seek for time and cost certainty and quality. Designers focus on aesthetics, functionality and a minimal use of resources. Conversely, contractors expect feasible methods, viable schedules and a profit margin commensurate with the transferred risks. The divergence of objectives can hinder team cooperation and encourage an adversarial approach. Selected due to their reputation, designers will focus on quality, whereas contractors, hired by competitive tendering, tend to concentrate on efficiency and economy (Bobroff, 1991; Nam; Tatum, 1992; Barlow et al., 1997).

Architects have been accused of abandoning their responsibilities within the project team (Weingardt, 1996) and studies point out that they have been increasingly replaced by contractors and project managers in the design management role (RIBA, 1993; Gray *et al.*, 1994), due to poor communication with clients and faulty cost and time management. The Tavistock Institute (1999) recommends the appointment of architects to integrate the design, and for other professionals to manage the project, since the latter involves unattractive duties to the architects that can be consequently neglected.

Clients' participation at an adequate level can demonstrably enhance their satisfaction with the investment and the likelihood of meeting their goals (Davenport; Smith, 1996). If clients adopt practices that promote a collaborative environment, the stakeholders will be encouraged to increase the quality and efficiency of their services in all stages of the process (Jawahar-Nessan; Price, 1997).

The procurement route can arguably influence the project performance and the integration between design and construction. The selection of procurement routes should consider aspects such as project type, building complexity, design and construction schedule and budget, and client organization and experience (Chan; Chan, 2000). Love *et al.* (1998)

suggested a range of criteria to establish the client requirements and inform the procurement choice: speed during design and construction, variability, flexibility to design changes, quality, protection against risks, complexity, responsibilities, total price and arbitration.

POTENTIAL DIFFICULTIES FOR INTERNATIONAL BUILDING DESIGN TEAMS

Despite recent developments in information and communication technologies, the communication between different organizations or even within a single organization has been pointed out as one of the main drivers of failures in construction projects (Franks, 1998). A study carried by British insurance companies pointed to poor communication and lack of coordination as primary drivers of client dissatisfaction, claims, frustration with unattended items, lack of positive relationships and incomplete information (Brown, 2001).

Communication and functional issues, which involve not only the organizations but also the individuals, cannot be ignored. Without an analysis of individual skills, cultures and interests, there will be little understanding of roles and respect for leadership structures, which can intensify the rivalry and reluctance to cooperate. Issues such as roles, cultures and communication must be addressed if personal skills are to be optimized on behalf of the team (Brown, 2001).

Information and communication technologies have rapidly evolved in recent years. Companies have developed collaborative systems and have started to offer services that enable project team members to cooperate in a virtual project environment. Potential benefits of the collaborative systems can include reduction of communication failures, savings with posting and photocopying, speed, safety, privacy in data transfer, automatic issue of reports and elimination of document control and distribution procedures (Chinowski; Rojas, 2003).

However, project members tend to operate in isolation within collaborative systems, which inhibits the establishment of trust and the awareness of individual roles. Therefore, project managers need to reinforce individual roles and conciliate team members' expectations throughout the project. They should also set parameters for information exchange to reduce the likelihood of exponential increases in data flow or an information overload. Consequently, remote project teams can benefit from leaders who are able to communicate and establish relationships (Chinowski; Rojas, 2003).

In this context, international design teams can theoretically aggravate the difficulties for communication and collaboration, due to factors such as remoteness, lack of personal relationships, preconceptions, lack of adequate technologies to support communication and data transfer, language differences and different individual and organizational cultures. Despite the advantages of hiring foreign offices, such as technological transfer, adoption of innovative design concepts and awareness of aesthetic issues, there are potential disadvantages that should be properly managed to reduce the likelihood and impact of their occurrence.

Wang (2000) lists some difficulties in the involvement of foreign designers in China: selection by *competition of ideas* did not consider the size, reputation and capacity of the design office; lack of compliance with local standards that induced design changes; difference in plans and specifications that required further detailing by local design institutes; the fact that foreign designers are not used to the local market and local clients are not used to the amount of imported components installed in the building; the insufficiency of communication techniques; the differences in the languages; the distance (for travel); and the need to hire local offices to redraw the plans and specifications. On the other hand Wang (2000) also highlights the relevance of the functional arrangement of foreign and local design teams for project performance. Appointing the foreign designers for the coordination can bring about advantages, such as fidelity to the original design intent, but contractors may find difficulties during the construction. Alternatively, the client can assign a local design institute to detail the plans and specifications so as to enhance the design understanding by local contractors. Wang suggested the involvement of foreign designers in the detail work, and the appointment of local design institutes from the project outset in order to adapt plans and specifications to local standards and enhance the understanding of the designs by the local contractors. It is assumed that this functional arrangement can prove equally beneficial in Brazilian projects that involve foreign design firms.

CASE STUDY RESEARCH METHODOLOGY

According to Yin (1994), the technical scope of the case study can be defined as “an empirical investigation that observes a contemporary phenomenon in a realistic context, especially when the boundaries between the phenomenon and the context are not clearly evident.” Investigations that focus on the linkages between organizations may require the use of multiple sources of evidence and the consultation of multiple units of analysis to produce more reliable outcomes. Therefore, semi-structured interviews were applied to seven professionals involved in a case study project: representatives of the construction firm, designers and project managers. Based on the reviewed literature, the interview questions comprised closed and open questions regarding the following variables:

i) integration: quality of interaction between project team members;

ii) project performance: time and cost certainty, compliance with client’s objectives, and absence of claims;

iii) iii) procurement: method for the selection and organization of the project teams for the obtainment of a building by a client. The selection criteria for the project considered the participation of Brazilian leading companies that have already implemented a quality management system.

COORDINATION PROBLEMS WITH FOREIGN DESIGN IN COMPLEX BUILDING

With a total floor area of 82,000 square metres and an estimated cost of R$ 160 million, the case study project creates a distinctive reference in São Paulo’s landscape. A Guaranteed Maximum Price contract divided into four progressive stages was adopted. The contractor was selected through a closed bid followed by a negotiation stage. The selection criteria took into account technical, economical and financial criteria. The original design was developed by offices located in Chicago and New York, and then adapted by local architecture and engineering firms. A project management office from

Chicago settled a branch in São Paulo to support the owner in the project. An Argentine designer that worked for the client on another project in South America was responsible for the adaptation of the structural design, originally developed in the United States. The organisational structures for the project and the design team are shown in Fig. 1.

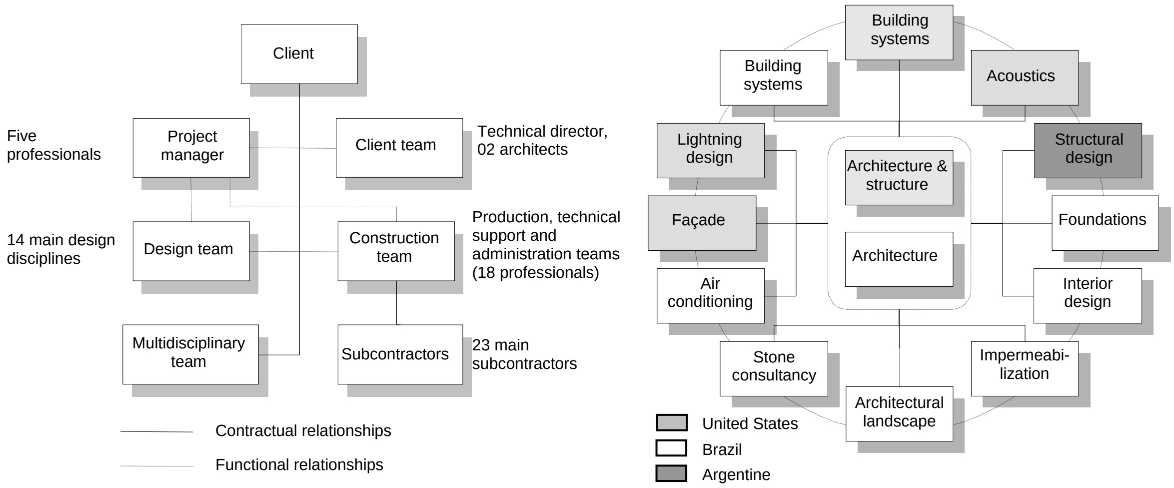

Figure 1 - Project and design team organizational chart

The case demonstrated that the appointment of foreign designers induces innovation and technological transfer, but can adversely impact the design management as a number of technical, managerial, cultural and economic factors, such as the development of the local supply chain, must be analyzed in advance. In this context, the design management demands a careful management of the work scope for each designer, an intensive configuration management, clear authority lines, mutual understanding of roles and responsibilities, interface management and an adequate selection of the local practices. The design management may be also influenced by the organization of the design team or the roles and responsibilities assigned to each designer. The following items discuss some of the difficulties faced by the project team due to deficiencies in the design management for the case study project.

Deficiencies in the selection of local and foreign design offices

The design concept was praised as outstanding and innovative by the project team. However, the team members admitted that the detailed design responsibility should have been assigned to local Brazilian offices from the outset of the project, due to their greater familiarity with construction methods and faster decision-making capacity. However, the local design offices were considered unsuitable as the project was complex. According to the contractor, “it’s inconceivable that one of the largest design offices in São Paulo doesn’t know dry wall. This reflects a wrong selection of partners” (contract manager). The design coordination was also criticized: “When you assemble designers, they don’t talk to each other. The coordination is not done or if it is done, it is not well done”. According to a project manager, “the architects are considered efficient when they’re able to make drawings compatible. But they’re not always suitable to coordinate”.
The structural design was severely criticized by the Brazilian engineers: “A structural engineer could find examples of solutions adopted worldwide. There isn’t any standardization. They possibly used all the solutions available in the concrete books”. The

structural design was considered conservative not only due to the lack of specialization of North-American designers but also to their lack of trust regarding the quality of the Brazilian construction process. A consultant hired by the construction firm reviewed the structural design and found serious errors, such as beams with only 50% of the required reinforcement, which would endanger the building rigidity.

Difficulties in the use of the foreign designs

The team members criticized the assignment of foreign offices to detail the design. Despite the innovation assured by the incorporation of the original design intent, it raised further difficulties for the design management, since suppliers usually play an essential role in the design process in the United States. Despite international experience in more than 50 countries, the foreign design practice simply assumed that Brazilian suppliers would develop the shop drawings. As North-American offices delivered the construction documents, the Brazilian contractor noticed that plans and specifications were insufficient to inform local subcontractors and suppliers. This failure led to delays and hampered the mutual understanding of design team members' roles and responsibilities.

Initially, a Brazilian architect, who worked for the foreign practice, was intended to coordinate the design. However, it was not feasible, seeing that foreign designers "never made decisions during meetings. They're technically defensive. As the project was delayed, it wasn't working. Foreign designers don't overcome contract terms and don't run unnecessary risks". The specification of imported components also raised difficulties for the construction firm, due to non-standard dimensions, connexions and executive methods. Moreover, the design team did not follow a precept of modular coordination in the project: "The modularisation of the concrete structure is different from the standards of Brazilian glass façade systems. There are different modularisations". The project also exposed weaknesses in the Brazilian supply chain: "It is unbelievable. A North-American plant delivered an innovative glass façade system faster than a local factory. It is unbelievable".

The poor quality of the briefing process

The architect stressed the importance of an intense involvement of the client's organization throughout the briefing process so as to mitigate the risk of late design changes: "If I had to start it all over again, I would start from the briefing. Closing a brief is one of the most important milestones of a project, but nobody seems to care about it. The client should have participated more actively. So, they came out later on with solutions used elsewhere, which could not be used in this building". The design management was largely affected by failures in the scope management and design change monitoring. The architect stressed the deficiencies in the briefing process: "The brief should be finished in a certain date. Then this date approached and there were a lot of changes. Nobody is to blame. We were not able to extract exactly what the client requested. This is a point that should be stressed".

Deficiencies in communication and information flows

The design management should define which information is relevant for each participant and establish communication structures, information flows, timetables and formats to transfer, record and distribute the information. The lack of communication procedures can lead to problems for the management, such as different levels of information between project teams or even within a single team. According to an engineer: “I received information previously and then a drawing with different information. Then I found that the designer did not receive all the necessary information as well. Consequently, he issued drawings that differed from what was agreed on earlier. There are three or four client representatives directly involved in the process. So, different people deal with the information and sometimes it does not reach all the recipients. I received information from the project manager that differed from that sent by the client. There are too many people involved, but not in an organized way”. The complexity of the project and the unusual number of participants hindered the communication process, which could have been simplified by collaborative systems and agreed upon procedures.

Deficiencies in the control and issuance of design reviews
The ongoing design changes and lack of criteria for the issuance of design reviews postponed the definition of critical items. The contractor criticized the designer’s lack of commitment with the project milestones: “We halted the works in some floors as we didn’t know how to go on. The most important floors for the client are exactly those where the design is more delayed”. Frequently, reviews did not solve design errors and slowed down the procurement of subcontractors and the distribution of the drawings to the site: “It seems illogical for me, because issuing a review is time-consuming. In some cases we received out of date reviews. Whenever a review is issued, it has to contain up-to-date information”.

The contract manager criticised the planning of the reviews: “We have drawings with more than 20 reviews. Why? It is linked to the lack of planning”. The process also exposed the lack of quality control procedures: “In the rush, designers deliver anything. Nobody reviews or coordinates. These problems occurred due to the lack of coordination. The drawings are simply incompatible”. The successive issuance of design reviews also hindered the distribution of drawings to the site. The construction firm almost sent the 14th version of a drawing to the site instead of the 15th one as the drawings were sequentially issued by the design coordination. Because decision-making in design review meetings was pretty fast, drawings did not always incorporate up-to-date information timeously. As a result, the construction firm had to modify its quality control procedure as to enable the receipt of incomplete or under-approval drawings, which were given partial approval and distributed to the subcontractors through coordination meetings.

Lack of information and design incompatibilities
The lack of information also affected the contracts with the suppliers and obliged the appointment of additional professionals to the construction team. Initially, a small team was assigned to manage lump-sum contracts, which were replaced by unitary costs contracts due to the lack of information. According to the contract manager: “I shouldn’t care about it, but I spend 20 to 30% of my time trying to treat the consequences of a poor design. The design is calamitous in this project”. The construction team reported material errors and omissions and stressed the absence of quality control procedures. The design errors overburdened the construction team and affected the cost estimation. An engineer pointed out that “all the technical, procurement and construction problems in this project are related to the lack of information”. A delay in the choice of the stainless steel of the façade postponed the schedule by four months. The contract manager complained:

"We're once more building without a design. The owner wants to launch the project, but had he decided to finish the design earlier, he could have saved time and money".

Demand of mutual understanding of roles and responsibilities
The architect criticized the lack of authority lines in the design management, despite other team players' argument that the coordination was clearly assigned to the architect. However, typical roles of the design manager, such as the control, registration, distribution and issuance of documents, as well as quality control and change management were undertaken by the construction team, who prepared a spreadsheet to guide the architect. According to an engineer: "We require it to build. I take a look at the drawings to identify missing or conflicting data and inform them through meetings, e-mails or letters. I collate the data and require the inclusion in the design".
These difficulties were partially caused by a poor understanding of the design team members' roles and responsibilities and a lack of recognized leadership. The dissatisfaction seemed to emerge from unrealistic expectations, preconceptions and conflicting requirements. The team members clearly presented different understandings of their roles and responsibilities, as suggested by the architect interview: "Someone has already said that deadlines were not established to be met. I haven't seen a single deadline met in this project. Now they set an unlikely schedule. They're getting nuts to meet it. But we will succeed and it is going to end up with a big party".

Divergent interests and expectations between project team members
Poor coordination procedures led to difficulties, such as different information levels between the project teams; "Three people from the client organisation worked directly in the process. So, I receive data from the project manager and from the client, what leaves room for doubts". Coordination procedures, implemented and supervised by each team leader, should have minimized the emergence of different information levels between the project teams. The architect emphasized the conflicting interests between designers and contractors: "This is absolutely normal. We're acting on the client's behalf. We are protecting the client's interest in this project; the contractor is protecting his interests". He also criticized the architect's detachment from the construction and complained about recent changes in the professional roles, which illustrate the rivalry between architects and engineers, and the reluctance to change: "Architects are unaware, what gives engineers the opportunity to enter the market. Engineers are not the same anymore. I used to learn with them. Now they become bureaucrats who manage the contract to meet the schedule, even if they have to destroy their partners. It is really a battle in this aspect".

Designer's detachment from time and cost management
The contract manager criticized the designer's detachment from cost and time management: "It is clear to me. There is an ancient detachment of designers from cost management that leads to construction problems. There is a deadline and I don't know what I am supposed to do for some floors. I am not inventing it". Excessive design changes and late decision-making affected the progress of the project and the relationship between the team members: "Frequently, the work is already done when a design change appears. There is rework and a demand for new cost estimates. We try to identify the cost as the design is issued and negotiate it with the client. Then we have to procure it once again. This demands a close contract management".

The contract could not be implemented as expected

The Maximum Guaranteed Price contract was praised by all parties as comprehensive and conducive to a high performance. According to the project manager: “It has a North-American structure. But it is organized and precise, and provides solutions for any contention”. Despite its strengths, the concept was not adopted, according to the contract manager, due to the lack of definitions in the design: “The cost should be reduced as the design was developed. However, we weren’t able to do it because we didn’t have complete design documents. We had to raise the price. So, we didn’t offer benefits to the owner”. According to the project manager, the inexperience affected the adoption of the contract: “This contract is clear for a North-American contractor. The second price is lower than the first. If the design hasn’t changed, the price is reduced. Differently, the contractor assumes a lot of things here based on assumptions”. The contractor disagreed: “The first cost estimate was R$130 million, because there was only a schematic design. The first GMP was R$128 million and the last R$146 million. Something happened, right?” He also questioned the so-called “concurrent engineering”: “The engineering has been invented in Brazil. I’ve been working for 23 years. Today, it is much worse than in the past. It is not concurrent engineering if this concurrence occurs during the execution. I can’t procure a façade if I don’t know the type of glass or aluminium. This is not engineering to me, it is something else”.

CONCLUSIONS

The assignment of foreign offices for construction projects can bring benefits, such as technology transfer and innovative concepts for the design. On the other hand, it poses difficulties for the design management as it may aggravate coordination and communication problems, conflicting interests and lack of mutual understanding of roles and responsibilities among project team members. Therefore, it can raise risks to the project and induce delays, cost overruns, variations, claims and adverse impacts in the quality.

The assignment of foreign offices can affect communication and team building due to different languages, distance, impersonal relationships, lack of face-to-face contacts, use of inadequate communication technologies and cultural singularities. In the case studied, the foreign designers adopted a defensive technical attitude and delayed decisions in order to avoid liabilities, which slowed down the project in a critical stage.

Assigning foreign offices for the detail design work can assure fidelity to original concepts and compliance with specified solutions. However, differences in the content of construction documents, local contractors’ and subcontractors’ lack of familiarity with foreign plans and specifications, and complexity in estimating and procuring imported items can arguably affect the design and construction management. The North-American construction documents presented a lower level of information compared to the Brazilian ones, since North American subcontractors are usually expected to detail the design. Furthermore, communication problems emerged due to the assignment of foreign designers. The local design team had to learn English and the foreign team had to learn Portuguese. According to the contractor, nobody in the design team was fluent in English. Certainly, this aspect postponed the analysis of plans and specifications, affected the resolution of doubts, hindered the communication or induced failures in the interpretation of the design documents. Teleconferences were utilized by design managers but without great success. Initially, plans and specifications were made available for downloading via the Internet. However, the system was abandoned as the majority of the subcontractors had never used it before. Additionally, the design documents distributed through the Internet bypassed the contractor's quality management system. Therefore, the availability of a technology does not guarantee its immediate success and acceptance by the project team as it commonly requires training and changes in the management.

The study also identified serious deficiencies in the design quality management, such as failures in the briefing and scope management, incompatibilities, interference, lack of criteria in the issuance of design reviews, excessive design reviews, lack of standardization and modularisation, and an excess number of late design changes. According to those involved in the project, these problems emerged due to three main reasons:

i) the project's unusual complexity;
ii) deficiencies in the selection of the local design offices; and
iii) lack of precepts, tools and techniques for the design quality management.

Although the volume of information exceeded expectations, it is assumed that a careful design planning and the adoption of simple precepts, such as the single statement of the information, could have reduced the problems faced by the project team. The spreadsheet developed by the contractors denotes a proactive approach that should have been encouraged. The design managers could have agreed upon an information demand schedule with the client and construction teams. Presumably, this initiative was not taken due to the conflicting interests, lack of trust and absence of genuine leadership within the project team.

The case study has highlighted some potential impacts of the trend for globalization in the construction industry, such as the purchase of goods and services in international bids and the establishment of international design teams. Remote design teams promote innovative personal and professional relationships, but conversely may create technological, managerial and organizational barriers for the supply chain integration. Therefore, innovations in management, technology and human resources are required as to establish trust and strengthen the cooperation in international design teams.

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BENCHMARKS FOR VALUE – DEVELOPMENT OF A BENCHMARK SYSTEM FOR THE DANISH HOUSING ESTATE

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Abstract

Low productivity, lack of quality and high amounts of defects in new buildings has been issues for debate in Denmark for the past several years. Numerous activities have been initiated to improve these conditions and recently benchmarks have been introduced as a prerequisite when bidding for governmental building projects. Existing benchmark systems are primarily focused on building process efficiency from the contractors' perspective. 'Benchmark system for the housing estate' (NBB) is developed with the clients as the target group and uses the building as an object for the benchmarks. As part of NBB, a method for evaluating standard and quality has been developed further; enabling benchmarks for buildings with regards to quality corrected values. This is seen as a vital contribution to the improvement of quality and productivity of the Danish housing estate.

Keywords: Benchmark system, client, housing, standard, quality.

INTRODUCTION

For several years the low productivity in the building sector has been an issue for debate in Denmark. Also the lack of quality and the amounts of defects has been criticised. Since 1971 when the law concerning governmental building projects was adopted, building projects for the Danish Government have to be carried out in the economic most advantageous way with consideration to the planned use and future operation (Statsbyggeloven, 1971). Nevertheless even today also governmental building projects result in delays, increased cost and defects.

Numerous Danish activities have been initiated to improve these conditions, for instance 'Project House' and 'Process and Product development in Building' (Bertelsen, 2001; Erhvervsfremmestyrelsen, 2001a; 2001b; Bang et al., 2001). Based on these initiatives it is concluded that two of the fundamental principles in the construction industry have to be changed in order to improve the productivity: the organisation of a building project and the right of the partners in a building project to independently organise their own part of the building process. Another result of these initiatives was an instruction for evaluation of standard and quality of housing projects, aimed at supporting both clients, dwellers and partners in the building project (By- og Boligministeriet, 2000). This instruction proposes a homogenous and systematic method of describing standard and quality, which includes both qualitative and quantitative data.

Parallel with these initiatives, the establishment of the Danish Building Defects Fund (BSF) in 1986 has resulted in a decrease in the amount of failures and damages in public funded housing projects since the beginning of the 1990s. Since 2001 BSF has published benchmarks for failures on all housing projects finished in 1998 and later to counter the competition of different benchmark systems marketed by private companies.

In order to further motivate the building sector to improve their performance, benchmarks have been introduced as a prerequisite when bidding for governmental building projects in Denmark (Erhvervs- og Byggestyrelsen, 2004). Since Jan 1, 2005 contractors have been met with the demand to document various Key Performance Indicators (KPI's) and to present a 'company grade book' when bidding for governmental projects. According to the departmental order six types of KPI's are to be documented: (a) observance of deadlines; (b) quality expressed by the amount of deficiencies; (c) working environment; (d) efficiency; (e) costs; and (f) client satisfaction.

In due time it is furthermore expected that the consulting engineers and architects involved in governmental projects will be benchmarked in concordance to these KPI's, and that other types of building projects, first of all public funded housing, will be governed by similar regulations. In this paper the development and contents of a new benchmark system for the housing estate is described. Differences between this and an existing system are lined up and the perspectives by using the new benchmark system are discussed.

BENCHMARKING IN CONSTRUCTION

Project success has been a topic in the construction management field for decades. However, to be able to perform a complete measurement of a project success, based on more than pure intuition, a consistent framework and methodology is needed. Cost, time and quality are the three basic and most important performance indicators in construction projects (Chan and Chan, 2004), although increasing attention is directed at other measures such as safety, functionality and user satisfaction. Benchmarking is viewed as an effective way to help organisations, companies or clients to deliver better services and to continuously improve their performance, i.e. to secure project success (Lam, Chan and Chan, 2004). Especially, benchmarking is viewed as vital for introducing new ways of delivering building projects, forced by the increased complexity of buildings, the increased demands for reduced design and construction periods, and the need to improve the project performance or project success.

Industrial-wise, benchmark systems have been under development for several years. A wide variety of different types of benchmarking are described throughout the literature, ranging from comparison of companies (Atkin, Betts and Clark, 1999; Barber, 2004) to product, performance and process benchmarking (Garnett and Pickrell, 2000). However, in the construction industry benchmark is a relatively new phenomenon owing partly to the fact that only limited benefits of systems developed for product based industries could be expected in a temporary project based industry as the construction industry (Garnett and Pickrell, 2000).

During the 1990s, businesses have focused increasingly on the fulfilment of client needs and expectations. Therefore it is vital that a benchmark system designed for the construction industry include KPI's for quality. In the literature quality is often translated with the meeting of (technical) specification or the amount of deficiencies, which are the easiest part to benchmark. Also they are the prime properties when industrial processed products are evaluated. However, it is argued that benchmarks on building quality are more complicated and should include several other aspects pertaining to e.g. the use of the building and whether client requirements are met. 'Benchmark system for the housing estate' is not complete when it comes to evaluation and benchmarking of quality but it goes a step further than the traditional way of defining quality as discussed later on.

DEVELOPING A BENCHMARK SYSTEM FOR THE HOUSING ESTATE

The development of a new benchmark system for the housing estate is discussed in the light of an existing national benchmark system aimed at governmental building projects.

Setting the scene

In 2003 the Danish Centre for Benchmark Evaluation (BEC) presented a benchmark system for national construction and building project (BEC, 2003). The idea behind the system is, that every contractor bidding for governmental projects have to deliver a 'company grade book' based on benchmark scores for completion of previous projects. The primary KPI's are focused on process efficiency, e.g. labour productivity. The rationale for using process efficiency measures are described in a report from the Danish Ministry of Housing and Urban Affairs (2000, p.7):

"The price of a building depends on the efficiency of the contractor. Productivity based on added value per worker is a measure for company efficiency. Since 1970 the construction output has increased by only ten per cent while our neighbours (Sweden, Germany and the Netherlands) have experienced increases of up to one hundred per cent".

Each company participating in a governmental project are measured accordingly to the KPI's. Upon project completion the contractor is given a grade for each main KPI category as well as a score relatively to other contracting companies. When the contractor has been benchmarked on three projects the grade book is to be used in future bidding projects. An additional grade book for/on the client is also produced; containing the KPI's on the projects that a specific client has participated in. For competitive reasons the basic data behind the grades and in the system are available for the concerned company only, e.g. data pertaining information about the contractors project economy.

The system has been met with criticism from various parts of the sector, but nonetheless the system is entering its second generation, as KPI's for consulting engineers and architects are about to be included in the system. A part of the criticism have been about the fact, that the system can be interpreted as a "closed system" meaning that the more profound data is not public available, thus impairing the sectors' ability to learn from other's experiences. Furthermore some construction clients have raised doubts over the validity and the usefulness of the system, from a clients' perspective, claiming that although process efficiency benchmark may lead to better performance they will not necessarily lead to better buildings.

Seeing that this system eventually would encompass the social housing sector the Federation of non-profit Housing Associations in Denmark (BL) took initiative to finance the development of a new benchmark system, which to a higher degree would satisfy the clients' needs. This system should aim at public funded housing with clients, building owners and building managers as the prime target group. Rather than measuring contractors' process efficiency the building should be the primary object for the benchmark procedure.

Constructing the system
The set-up for the system ‘Benchmark system for the housing estate’ – NBB was specified by a group of public owners and construction clients who financed the project. The system should be relative simple to use, consist of a limited number of KPI's, primarily consist of data generated and already available through existing public information systems and databases, and be “generic” in terms of use on different types of building projects. In order to ensure that the system could be rooted quickly and effectively in the target group, it was decided that the benchmark system as far as possible should accommodate wishes from the prime target group, i.e. members of BL.

The Danish Building Research Institute (SBi) was appointed to conduct the preliminary analysis of the system and develop a structure for the system. SBi was found most suited for this task, based on the institute's previous experiences with development and testing of evaluation concepts, first of all pertaining standards for building technology and user-evaluated quality. Also SBi had experiences with concepts for documentation of prices, costs and delivery conditions, as well as evaluation of building process co-operation (e.g. Bertelsen, 1999; Bertelsen et al., 2001; Bertelsen and de Place Hansen, 2004; Frøbert Jensen and Beim, 2003; Gottlieb et al., 2004).

The set-up for NBB was discussed in detail with representatives from BL’s secretariat, member organisations of BL, and BSF. Also a larger group consisting of representatives from the National Agency of Enterprise and Construction (EBST), the Ministry of Social Affairs, the organisation Local Government Denmark, the local government of the City of Copenhagen, the Danish Association of Construction Clients, and BEC was given the opportunity to comment the system before the results were published.

System dependencies
As stated previously NBB has the client, the building owner and the building manager in public funded housing as the prime target group. The purpose of NBB is to contribute to a strengthened quality and efficiency in the housing estate including showing best practice for the price and quality. 70 % of the input for NBB is based on data from existing public systems, e.g. BOSSINF, BSF and the Danish Register for Buildings and Dwellings (BBR), and it is the intention that the implementation of NBB will be without further expenses for the client.

BOSSINF contains information on all public funded housing projects since 1992, e.g. the involved partners of the project, the cost of the main building parts and the size of the buildings and the apartments. EBST and the local authority uses BOSSINF to follow the main steps in the project, i.e. at the application for public support, at the competitive tendering, when the building license is given, and at completion of the building project.

BSF supports repairing of damages related to the erection of the building in public funded housing projects. Data from BSF contains information about the amount of failures and damages detected after 1 and 5 years of use. 1 % of the initial cost of a building project is paid to BSF to cover the obligations of the fund.

BBR is a nation-wide register established in 1977 that contains basic data on the complete mass of buildings and dwellings including an unambiguous registration of addresses. BBR is used by the authorities, the supply companies and the private sector.

For BL it was decisive that NBB was based on existing public databases to avoid that it would be seen as an unnecessary expense for the clients. Therefore, not only is NBB mainly based on existing data, it is also suggested to slim down existing systems, so that the implementation of NBB in total should be neutral in regard to the time used for the collection of data. Quite a lot of the data registered in the systems are seen as irrelevant, which means that they are not used and also they are not valued to be of sufficient quality.

System aim and content

NBB contains KPI's characterising the utilisation of areas, delivery conditions, changes and deficiencies, the building process and co-operation, prices and costs, as well as standard and quality. The system is inspired by the British 'Achieving Excellence Design Evaluation Toolkit', which has played a major part in the refurbishment of the British healthcare facilities (www.nhsestates.gov.uk).

Compared to the requirements in the Danish departmental order, NBB contains several additions, especially in relation to standard and quality, the utilisation of areas, changes and deficiencies, and prices and costs. These additions are expected to be important for best practice in the building sector and for the promotion of the productivity. Also these additions show where the client want to put more focus in future project management.

To keep NBB simple and useful, the KPI’s are in general given for the dwelling or the housing project as a whole regardless that they are based on information on a much more detailed level. The KPI’s are chosen based on the following criteria:

- create transparency concerning the cost/quality relationship
- contribute to show best-practice in the building industry
- make it possible to evaluate the competencies of the partners in a building project
- strengthen the development of the public funded housing sector.

The structure of NBB, the proposed KPI’s and the principles for collecting data are described in detail in (Bertelsen et al., 2005). In the following we have chosen to focus on the innovative aspects of the system compared to other national benchmark systems.

Innovative measures of NBB

NBB is designed to be an open system where all data are available for the public. Therefore, NBB opposed to e.g. BEC’s system does not contain data regarding the ability of the companies to earn money. These kinds of data are not seen as relevant for the client as long as the contractor is able to deliver the planned buildings at the scheduled time and price. Also NBB does not contain data regarding the efficiency, e.g. measured as working hours per square meter by the contractors. These data first of all reflects the level of industrialisation. Therefore, they are not relevant for the clients when different housing projects are to be compared.

NBB is based on four groups of data:

- basic data on the building project
- data on project completion and process co-operation
- data on building costs
- data on standard and quality of the building.

The innovative part of NBB lies in the addition of the fourth group of data regarding the standard and the quality of the buildings. The purpose of these data is to:

- enable price-quality comparisons of different types of buildings
- deliver input for determining standard criteria for measuring quality
- supply construction clients, partners and subsequently building residents with a tool to evaluate the standard and quality of housing projects.

In this context 'standard' relates to the building technology, as a combination of the specific technical solutions and the properties and execution of the building parts. The evaluation is carried out based on information from the year-one and year-five building inspections that are performed on behalf of BSF. As a part of this inspection BSF registers the specific components, technical solution and construction type of each main building part, e.g. outer walls or inner walls. A specific combination of the aforementioned elements of each main building part constitutes a 'reference type'. Each specific reference type is assigned a 'reference grade' according to a general estimation of the standard of this reference type relatively to other reference types. The point-of-reference for determining the standard of each reference type will among other things be taken in a combination of data on defects and service life. This grade can be adjusted with regards to finish and buildability.

'Quality' relates to the perception of the project delivered for the residents' point-of-view. The tenants cannot be expected to have any building technology insight. However, they can be seen as 'experts' regarding the actual use/usability of the building. The tenants are to evaluate the building based on their satisfaction with the design, shaping and facilities of the dwellings, the usability of the installations, and building surroundings and local environment. Each parameter is graded according to user satisfaction and a weighted average is calculated and expressed on a relative scale from A to E, representing the user evaluated quality. The standard and quality of a building is thus expressed absolutely according to choice of materials and technical solution as well as relatively according to user satisfaction. Consequently a price-quality and price-standard comparison can be produced as well as a standard-quality comparison.

CONCLUDING REMARKS AND IMPLICATIONS FOR THE FUTURE

Benchmark systems are developed and introduced in order to improve the building process and the building product, including identifying best practices. Ungan (2004) has identified the factors that have an impact on the adoption decision of manufacturing best practices. He concludes that cost of adoption, satisfaction with existing practice, and external pressures are the most influential factors.

The principle aims of the development the benchmark system for the housing estate was to: (1) anticipate a legislative move forcing public funded housing projects to apply to an existing benchmark system not suited their demands; (2) improve the standard and quality of public funded dwellings; (3) reduce the bureaucratic administrative report procedure. Therefore, with the findings of Ungan in mind, NBB should have a promising future.

According to Chan and Chan (2004) a benchmark system should be based on a limited number of KPI's, be useable on different types of building projects, and draw on a simple data collection procedure. Furthermore the KPI's should include both objective measures, such as unit cost, and subjective measures such as user satisfaction. NBB corresponds to a great extent with the KPI requirements proposed by Chan and Chan although NBB is more detailed e.g. when it comes to costs and quality. NBB also contains other types of benchmarks than Chan and Chan uses, such as 'Utilisation of areas', that relates to the functionality, and 'Changes and deficiencies' that in part relates to quality or efficiency.

Based on three case studies Chan and Chan’s primary conclusion pertaining to the limitation of a benchmark system was that KPI's based on data related to monetary values and profit are problematic. The reason is that project finances often are guarded by confidentially concerns and stakeholders might not be willing to disclose for analysis. This however is not an issue in NBB as it only is the construction client's organisation that is to deliver the data, and the client *per se* has access to all the necessary information required.

NBB is currently in its second implementation stage. The system organisation, manuals, databases, and training programs are under development. This includes an adjustment of BOSSINF and a discussion of the governmental requirements to the system. Full implementation and transition to operating stage is expected within the next 6 months, whereupon the first benchmark results will be readily available. It is the ambition to further explore the relationship between cost and standard and quality by relating the cost not only to standard and quality but also to the building index, the position of the site, the type of building, the size of the dwelling, etc. The discussion concerning how to define and describe quality in an operational manner is to be further explored in a separate paper. Also, it is the ambition to broaden NBB to other types of building projects and to other partners than clients.

Acknowledgements
The authors would like to thank the Nykredit Foundation for the financial support.

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CONSTRUCTION ENGINEERING DESIGN IS AN ELEMENT-CONSTRAINT-ELEMENT NETWORK OF INFORMATION EXCHANGE

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Abstract
This paper describes an aspect of an ongoing research project that has been attempting to map the design process by using design elements, in sufficient depth to possibly develop tools for a predictive model of the process. The starting point is that, each construction element and its components have a generic sequence of design activities. The specific building introduces one set of constraints that tailor the design element. There is then a second set of constraints produced due to the interaction between the elements of the design. Therefore, the selection of a component may impose a set of constraints that will affect the choice of other design elements. Thus, a complex design decision can be seen as an interrelated Element-Constraint-Element (ECE) sub-net. This has been illustrated through an example of a bottom up analysis of a specialist pre-cast concrete designer's needs at the working drawing level of detail.

Keywords: Design Management, Information flow, Process Modelling

INTRODUCTION
From our observation the process of design is largely developing a solution that is highly dependent upon inputs of information from many sources. The primary source is the knowledge of the individual designer supplemented by knowledge from other designers, usually of a specialist nature. One could argue that the quality of the design is dependent upon identifying the designer with the correct knowledge base and the source of the correct specialist input information (Emmitt 1999). The information sources would need to be appropriate to the technology that is being used in the building. For example steelwork specialists would be needed to calculate the connection details.

One of the first approaches for better understanding of the design process was developed in the late 1960s for power stations (Farell R 1968). Here it was seen that the actual time to design was in the hands of the designer but that workflow was improved by an awareness of the inputs and outputs to the rest of the designers in the project. A simple tabular graph on a timeline showed inputs and outputs from which each designer could determine the relative importance of their tasks. By raising an awareness of the relative importance of communicating information to other designers there was a significant increase in efficiency. However, it was realised that the total network of interchange was far too complex to be represented on a single diagram. Therefore this research has focussed on developing an, as automated as possible, map of the design process using an elements approach that embodies the production of information outputs and the transfer of inputs and outputs and the linkages to form the process to overcome the limitations of the paper based approach of Farell. Design processes can be described as incomplete, ill structured, changeable, difficult to be modelled and context-sensitive (Coles E J and Barritt C M H, 2000) and designers have rarely looked at the structure of their knowledge therefore; it is necessary to generate a map of the design process to understand their decision-making sequence (Austin, 2001).

A review of the limited number of available design process models such as: Construction Process Model (Karhu, Keitila and Lahdenpera, 1997), GEPM (Karhu, 2001) and ADePT (Austin, Baldwin, Li and Waskett, 2002), showed that all are based on high level process models of design activity. This paper proposes that each technology has a specific (and standard) model that is modified by association with other technologies. The elements of each technology are held as design objects with their information input requirements and outputs to other potential design objects. When selected the objects link to create a network of interchange - the Element-Constraint-Element (ECE) network. The approach that has been used to generate the specification of the elements has been to examine the information that must come out of each design element at the component production and site assembly stage. This is a bottom-up driven model. The ability to generalise will be dependant upon the rules inherent in specifying the element and information needs and this is the content of this paper. A particular approach has been developed for recovering the rules for each object and for potentially developing the total knowledge base.

DEVELOPING AND MODIFYING GENERIC MODELS OF DESIGN

The proposition is that each construction element or component has associated with it an established sequence of design processes. At the right level of detail this would be common or generic. The set of activities should be common wherever similar use of the technology is made. When using the component in a specific situation the generic model would be adapted. One issue therefore is to define an appropriate level of detail that permits the generic patterns of the processes to be found. This is not to be confused with the notion of the iterative nature of the design process. Each step in the process may well contain considerable iterations as the process is defined in a broad sense. Much iteration occurs because the designer is unaware of or has yet to receive input information to the process. This was the thrust of the work of Farell and the main reason the current work focuses on information requirements and flows at component level. If the necessary inputs can be defined then iterations may be reduced so improving the execution of the process.

The constraints that control the selection from, and the modification of, the fundamental sequence in a design process can be classified in two dimensions. First are the constraints that tailor this design element to the specific building. The second are the constraints produced due to the interaction between the elements of another technology. In other words, the choice of elements that satisfy a design problem and the interfaces between the technologies produce a network and a complex design decision can be seen as an interrelated Element-Constraint-Element (ECE) sub-net. In practice, it is difficult to identify the network as it is complex, i.e. the number of different patterns of relations between elements increases when the number of different elements increases. Thus, a proper approach to solve the complexity could be:

i) Select one design element or component at a time and predict the implicit constraints.
ii) Identify the constraints, produced when linking to other design components.
iii) Develop the resulting model of the design process

A decision has to be made as to the level of detail for modelling. It would probably be impossible to model every component due their variety. As Farell found it is best to let the designers determine the scale of work in each process whilst managerially it is more important to determine the information flows. The choice here is the general level of component, e.g. cladding panel.

METHODOLOGY

The major issue of design management that this work addresses is the supply of detailed information to either the site or for component manufacturing stage. Nowadays specialist trade contractors produce this information (Gray and Hughes, 2001). Therefore the approach was to examine the information generation process of a specialist trade package, with the objective of identifying the best practice set of activities from these experts. Best practice has been defined as the elements' sequence and information flows that would enable them to produce the most effective technical solution in the most efficient manner. Pre-cast concrete cladding and its connection to a structural frame was chosen to develop the approach. This was a suitably complex component that has a clearly articulated interface with a structure. The process of developing the information for the knowledge base is summarised as:

i) A modified Delphi approach to knowledge acquisition was adopted: first the available literature was studied and an initial model of the elements and information needs within the design process for pre-cast cladding was assembled; secondly this was evaluated by experts in the pre-cast concrete industry followed by several iterations to achieve the final model.
ii) An input/output analysis of the data and decision transfer points between the pre-cast cladding design and the structural design enabled the information flow within and between the technologies to be identified.
iii) These steps, when combined enabled the creation of a generic model that would be modified for each of the panel / structure combinations.

The available technical literature was used to generate an initial map of the decision process. The initial map of the process for the particular sub-design was presented and inspected for each entry. The experts used examples to confirm the correctness of the map and supplied further examples of different approaches to expand or delete entries.
To achieve the flexibility necessary for future modelling the different configurations of the element-constraint-element network are presented in the KBE (Knowledge Based Engineering) format (Al-Bizri, 1995).

Developing ECE nets AS Generic Models

Experience of knowledge base development has shown (Gray and Little, 1985) the context must first be described before the abstracted elements can be described in a suitable way for a knowledge-based approach.

DESIGN CONTEXT FOR KNOWLEDGE BASE DEVELOPMENT

Pre-cast architectural cladding panels are usually non-load bearing, but load bearing panels are used when they provide the most economic structural solution. Designing non-load bearing pre-cast concrete cladding panels and their connection to the structural frame is a complex process, which involves designers from different design teams and organisations. The architect, structural engineer and cladding specialists are usually involved.

The design of non-load bearing pre-cast concrete cladding is highly interdependent with the structural frame. The units and their fixings are designed to withstand self-weight, wind loads and the lifting and handling stresses during manufacture and erection. Non-load bearing pre-cast concrete cladding is often in panel form. The process of designing non-load bearing pre-cast concrete panels and their relationship to the structure involves the architect, structural engineer and the trade contractor. The main factors, which the designer has to consider in determining the panel size, its shape and composition are discussed below. Each section considers first the design issues for the panel and then the constraints when fixing to the frame.

The Size of the Panel

Architectural and structural requirements and the practicality of manufacture, the transportation and weight of unit for lifting determine the size of the panel. From the elevation and detail drawings provided by the architect the cladding designer checks the panel's width and length. The thickness of the panels can be determined according to the loads. Thus, an approximate self-weight of the unit can be calculated. For each fixing location to the structure, the structural engineers should check the loads on the structure as it may affect the column dimensions and spacing. Also the structural engineer should consider the effect of the weight of the cladding panels on the edge detail of the structural slabs.

The Shape of the Panel

Panels can be of either uniform thickness or thin panels with reinforcing ribs. The profile of the panel is defined by the panel's web thickness, plus the thickness of the horizontal nibs and the vertical strengthening ribs (see Figure 1).

<u>Panel web thickness</u>: The panel web acts as a slab spanning between the vertical strengthening ribs. The size is determined by the requirements for concrete cover to the reinforcement, which is determined by the span. Increasing the number of ribs can reduce the thickness of the panel.

<u>Horizontal nibs:</u> There are two types of nibs, restraint and support nibs. Restraint nibs are used to tie the panels to the structure whilst support nibs are used to fix the panel to the slab. The depth of the support nib (d in Figure 1) is sized according to the loads and the support needs onto the edge of the structural slab given the relative tolerance in the panel and the structure. The height of the nib (h in Figure 1) is partly determined by the type of fixings in addition to providing sufficient space for reinforcement and suitable concrete cover.

<u>Vertical strengthening ribs:</u> Vertical strengthening ribs act as beams to transfer dead and vertically applied loads to the structure, thus the loads and the distance between supports determine the depth of the ribs (d in Figure 1). Other factors that affect the depth of the rib are the fixing points and the drainage requirements at the edge of the structural slab. The breadth of the rib (b in Figure 1) is determined by the fixing requirements and the dimensions of any columns at the panel junctions. Also the breadth should be sufficient to cover the vertical reinforcement.

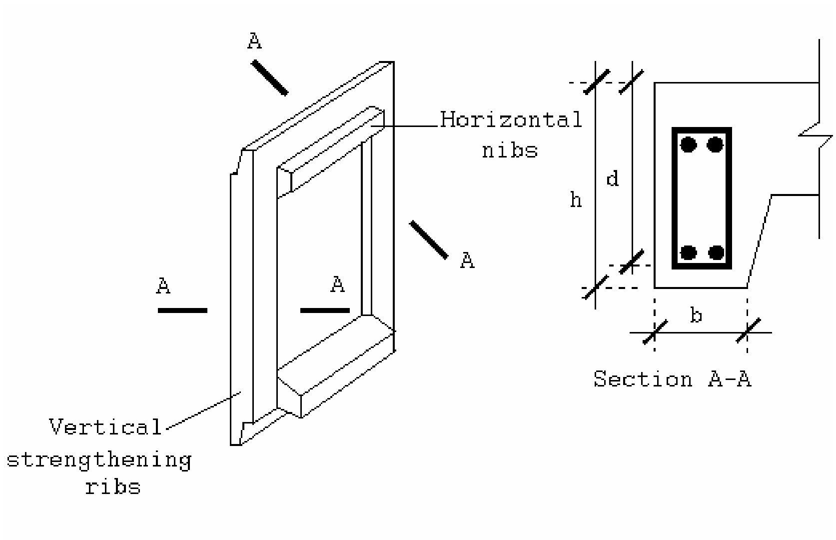

Figure 1: Strengthening ribs and support nibs

Uniform thickness panels are preferred, but coffered edge panels reduce the self-weight of the panels, as well as providing a joining profile for the panel. Information about the edge of the structural slabs and the column dimensions is required from the structural engineer, so that, the cladding designer can give sufficient allowance for the depth of the horizontal nibs and vertical ribs to be fixed to the edge of the structural slabs. The information provided about the column dimensions helps the cladding designer to determine the breadth of the vertical strengthening ribs in the instances where the column will be behind the panels. Once the cladding designer determines the depth of the horizontal nibs and the vertical ribs, the self-weight of the panel and the other loads that the panels might be exposed to, are calculated.

The Type of the Panel

There are two main types of panels: mullion and spandrel units. A mullion panel extends from floor to floor whilst a spandrel panel spans between columns or from window to window. The architectural drawings provide the cladding designer with information about the height of the panels, but the design of the structural slabs affects the decision on the height of the panels as their depth can affect the height of the spandrel panels and the floor to floor height, therefore, this will affect the height of mullion.

Panel Supports and Fixings

Panels can be either supported at the base or hung from the top. Generally, bottom supported panels are preferred as the panel will be in compression and the risk of cracking is minimised. The nibs on the panels transfer the loads to the structure. In the case of the uniform thickness panels the fixing would be designed to transfer the total load. Fixings can be either load bearing or restraint (see Figure 2).

<u>A load-bearing fixing</u>: is designed to transfer the weight of the cladding units to the structure. Each panel should have at least two supports positioned either at the bottom of

the panel in the case of bottom supported panels or at the top of the panel in the case of top-hung panels.

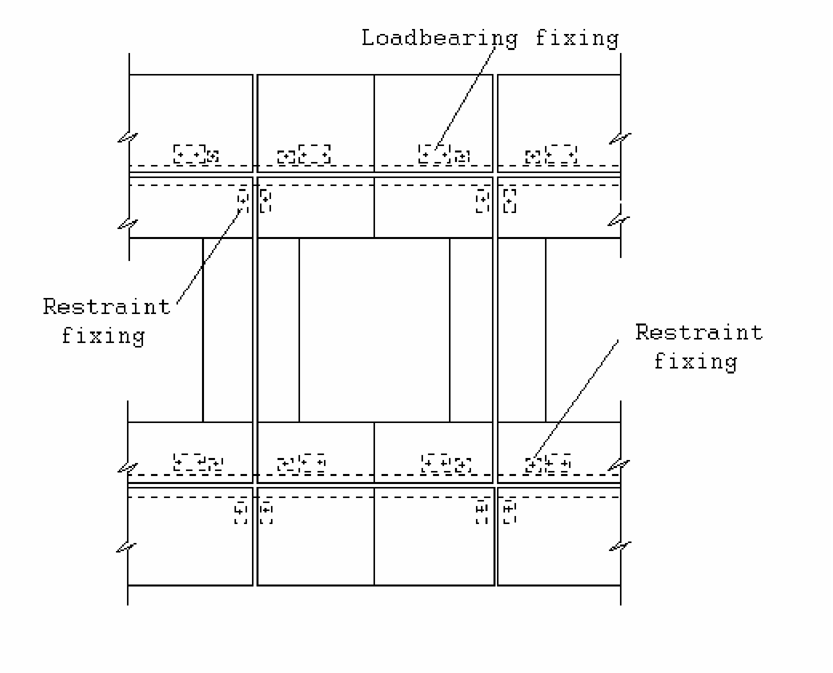

Figure 2: Layout of load-bearing and restraint fixings

A restraint fixing: ties the panel to the structure. It may also used to transfer horizontal forces, such as wind pressure. Each panel should have at least four restraint fixings preferably positioned near the corners.

The fixing method to the structure can be either by angle cleats or dowels:

Angle cleats: are used to restrain the panel at the top, and may be used to fix the panel at the base. The size of the angle cleat is calculated according to the loads. Angle cleats should be designed to give dimensional adjustment in these planes: vertical adjustment, horizontal adjustment between the cleat and the panel to the face of the building and linear adjustment parallel to the edge of the slab (see Figure 3). Vertical adjustment is provided by slotted holes in the angle cleat and packing pieces allow horizontal adjustment. Cast-in channels provide adjustment parallel to the edge of the slab. Cast-in sockets, drilled-in sockets and expanding sleeves can also be used to provide the fixing at the edge of the slab. Figure 3 shows the allowance in the design of angle cleats of: a) adjustment parallel to edge of the slab, b) vertical adjustment and c) packing for positional adjustment.

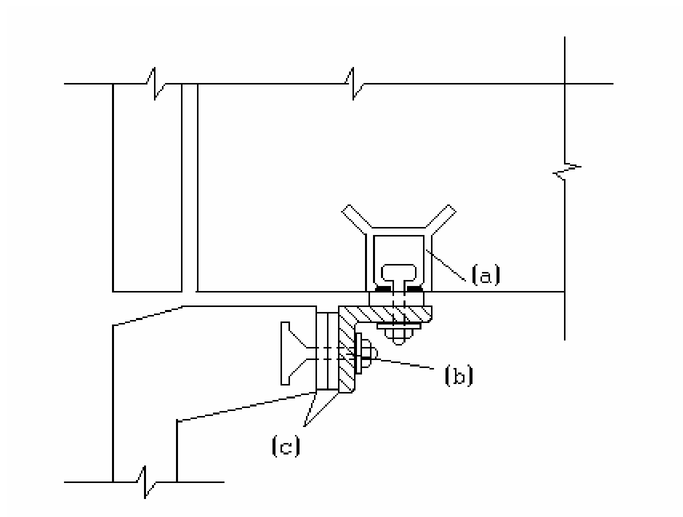

Figure 3: Allowance in the design of fixings for adjustment

Dowels: can be used to restrain the panel through the bottom support nibs into the slab. Restraint dowels are used also to restrain the top and bottom edges of adjacent panels (Figure 4 top). The dowel system is normally slotted so that it does not restrict thermal movement. Dowels are cheaper than cleats, easier to assemble and more flexible in accommodating dimensional inaccuracies in the structure. A hole is formed in the panel and a pocket is cast into the in-situ floor to receive the dowel. Figure 4 bottom, shows the allowance in the design of dowels of: a) dowel, b) hole for bolt and c) loose cross pin.

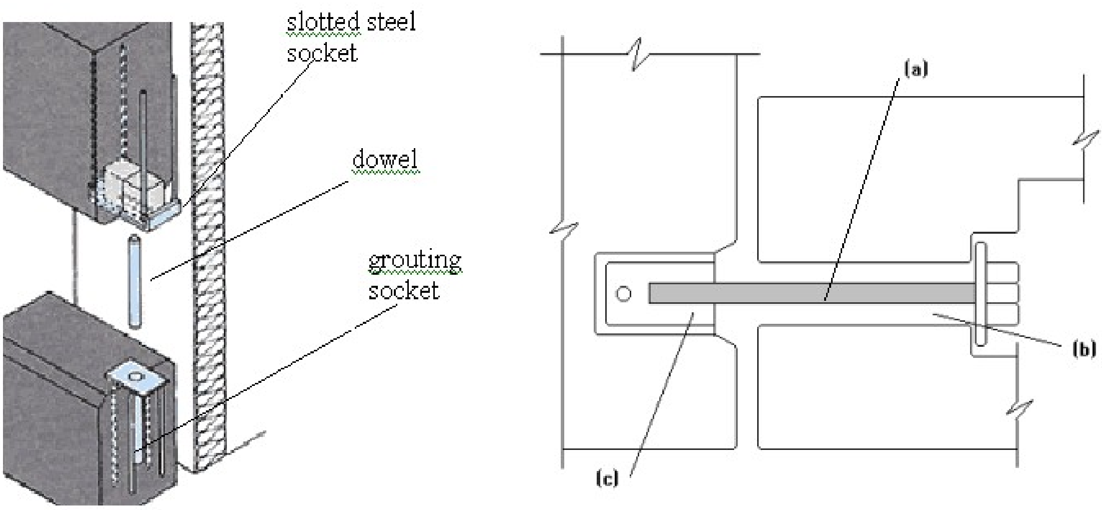

Figure 4: Allowance in the design of dowels for inaccuracy

Figure 5 shows possible combinations of dowel and cleat fixings. Type a and b, cleat fixings at the top and dowel or cleat fixings at the bottom are better for quick erection. Type c, is a safer fixing as the panel would fall inward due to its self-weight and wind loads if the fixings fail. The fixings should also permit vertical movements caused by the deformation of the structure or the movement of the panels. Inaccuracies can appear during construction. To overcome these inaccuracies tolerance must be allowed in the method of fixing to accommodate the variable clearance between the panels and the structure.

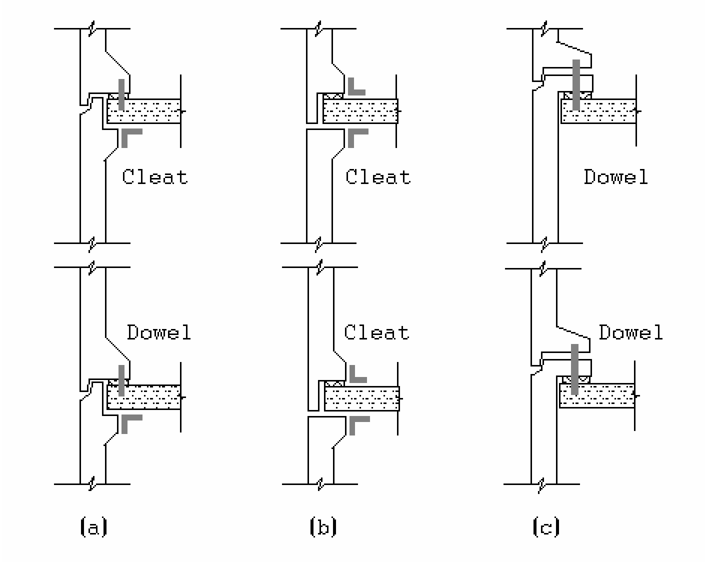

Figure 5: Various combinations of dowels and cleat fixings

The specialist cladding contractors prefer bottom-supported panels as the panel will be in compression. The specialist's first choice of fixing would be cleats, but the choice of base supported panels gives the cheaper option of dowels. When the cladding panel is fixed to an in-situ concrete slab there may be greater structural inaccuracy and cleats allow a greater accommodation of wider tolerance.

The cladding designer should provide the structural engineer with information about the fixings which will be used, as the choice of cleats, dowels or other types of fixing affects the design of the fixing points at the edge of the structural slabs. When the cladding designer chooses cleats the structural engineer can choose between cast-in channels, cast-in sockets, drilled-in sockets or bolts with expanding sleeves. Channels are the preferred method. If the cladding designer chooses dowels the structural engineer has to consider how to provide the pockets at the edge of the slab, with the resulting demand on casting accuracy.

ELEMENT-CONSTRAINT-ELEMENT SUB-NETS

From analysing the pre-cast concrete cladding design in relation to a concrete structure it has been found that there are four types of relationships between two elements in an ECE sub-net (See Figure 6). These can be expressed in the following logical statements:

Case 1: [e1] consequence [e2]

Example: Column dimensions have direct consequence on the width of the vertical strengthening ribs of the coffered edge pre-cast concrete cladding. This relationship between the column and the ribs of the pre-cast concrete cladding can be expressed by:

[e1] consequence [e2]

where:
[e1] is the column and its dimensions in the frame technology
[e2] is the width of the vertical ribs of the coffered edge pre-cast concrete cladding technology.

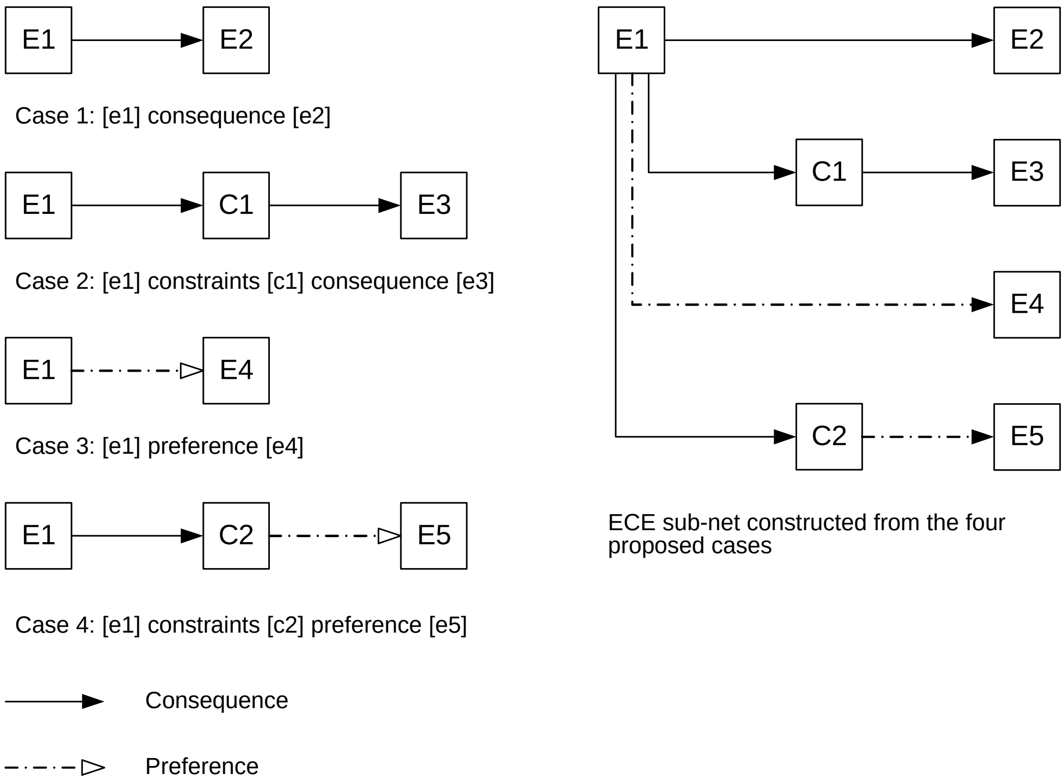

Figure 6: Types of relationships between two elements in an ECE sub-net

Case 2: [e1] constraint [c] consequence [e2]

Example: The depth of the structural slab affects the floor-to-floor height and the floor-to-floor height will be a constraint that will affect the height of the mullion of the pre-cast concrete cladding. This relationship between the depth of structural slab and the height of the mullion of the pre-cast concrete cladding can be expressed by:

[e1] constraint [c] consequence [e2]

where:
[e1] is the depth of the structure slab in the frame technology
[c] is the floor to floor height in the frame technology
[e2] is the height of the mullion of the pre-cast concrete cladding technology

In certain situations more than one solution is possible and whilst these are preferences other choices may be made. However, any model must make provision for such situation and the following two cases illustrate how the proposed model can advocate a preference by weighting one choice more than another.

Case 3: [e1] preference [e2]
Example: The choice of base supported pre-cast concrete cladding gives a preference to the choice of dowel as a fixing for the pre-cast concrete cladding. This relationship can be expressed as:

[e1] preference [e2]

where:
[e1] is the base supported pre-cast concrete cladding in the frame technology
[e2] is the dowel fixing for the pre-cast concrete cladding affecting holes location in the frame technology.

Case 4: [e1] constraint [c] preference [e2]
Example: The choice of in-situ structure slab causes specific tolerance issues and gives greater preference to the choice of cleat as a fixing for the pre-cast concrete cladding. This relationship can be expressed as:

[e1] constraint [c] preference [e2]

where:
[e1] is the in-situ structural slab
[c] is the tolerance profile
[e2] is the cleat of the pre-cast concrete cladding

A complex ECE sub-net results when combining the four generic cases of ECE relationships.

ELEMENT DEFINITION IN AN ECE SUB-NET

The definition of an element in an ECE sub-net could be seen as a relationship between elements in a hierarchy linked by either of the relationship can-be or dimension. **Can-be** is a relationship that links the higher level element of the hierarchy to more detailed elements, e.g. precast concrete cladding shape can-be uniform or coffered edge. **Dimension** is a relationship that builds a broad description of an element from a choice of features, e.g. the structural element has three dimensions, material, type, and plant. Material can be concrete, whilst type can be slab. Thus the design element, in this case, will be concrete slab. The following are examples of the sub-nets for particular decisions generated from the knowledge base of pre-cast concrete design in relation to a concrete structural frame.

Sub-net 1: Panel Dimensions - (See Figure 7)
Uniform thickness panels are usually preferred more than the coffered edge panels. However, the self-weight of the panel might influence this choice towards a coffered edge panel, as this would reduce the self-weight of the panel. A coffered edge panel also provides a better joining profile.

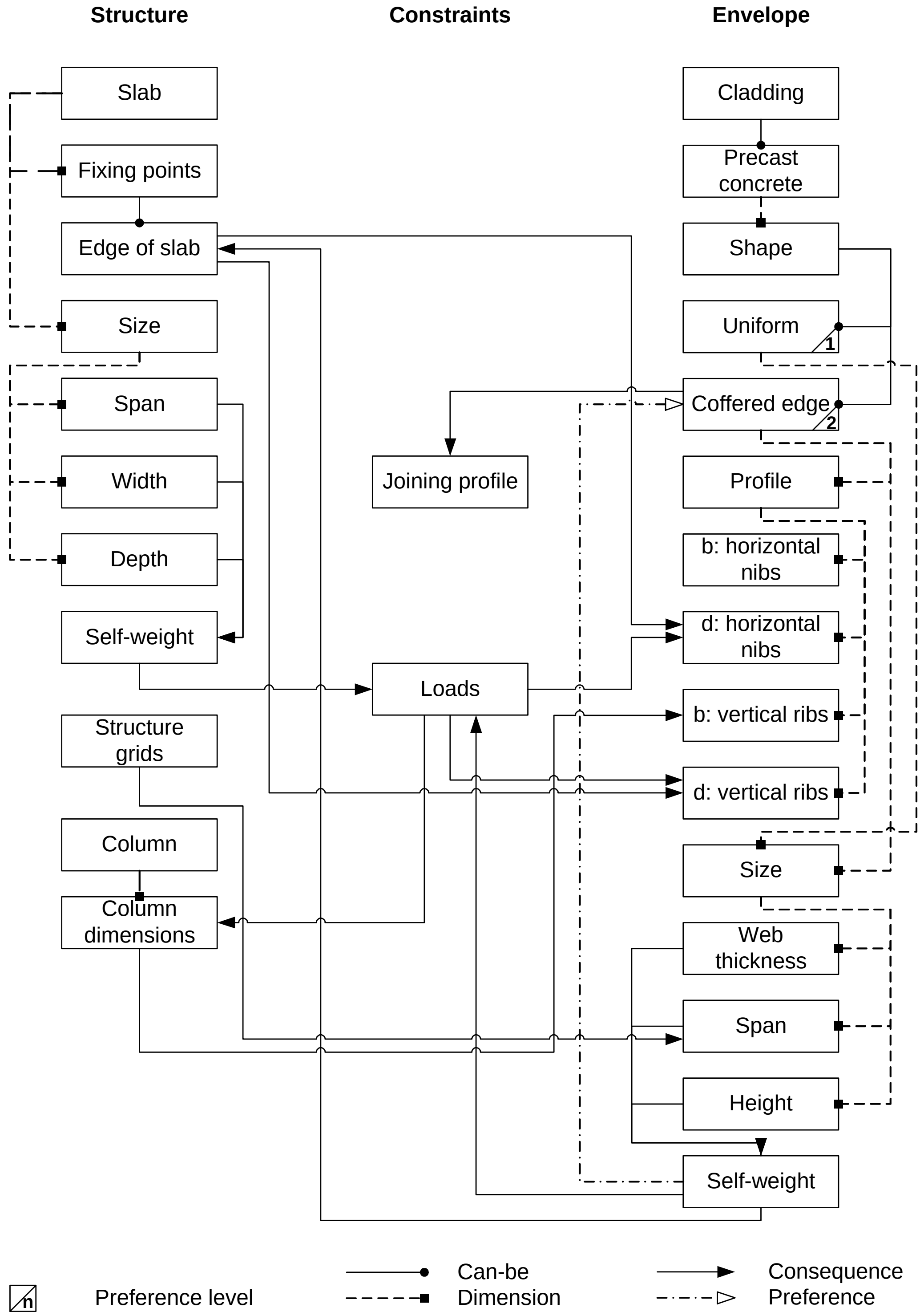

Figure 7: Sub-net 1 - Panel Dimensions

When a panel has a coffered edge, the loads that the panel is exposed affect the depth of the horizontal nibs and the vertical ribs. The design of the edge of the structural slab affects the depth of the horizontal nibs and vertical ribs, as they have to be large enough for the panel to be safely fixed to the structure. The column dimensions affect the breadth of the vertical strengthening ribs in the places where the panels face the columns. The size of the panel, i.e. web thickness, span and height affect the self-weight of the panel. Consequently, the self-weight affects the design of the edge of the structural slab so that it can carry the load over the length of the edge, as well as the loads at the fixing positions. The loads affect the column size and spacing.

Sub-net 2: Structures Dimensions - (See Figure 8)
The depth of the structural slab affects the height of the spandrel panels directly and the height of the mullion by affecting the floor-to-floor height. The floor-to-floor height affects the overall height of the building. Therefore, the thickness of the structural slab affects the overall height of the building.

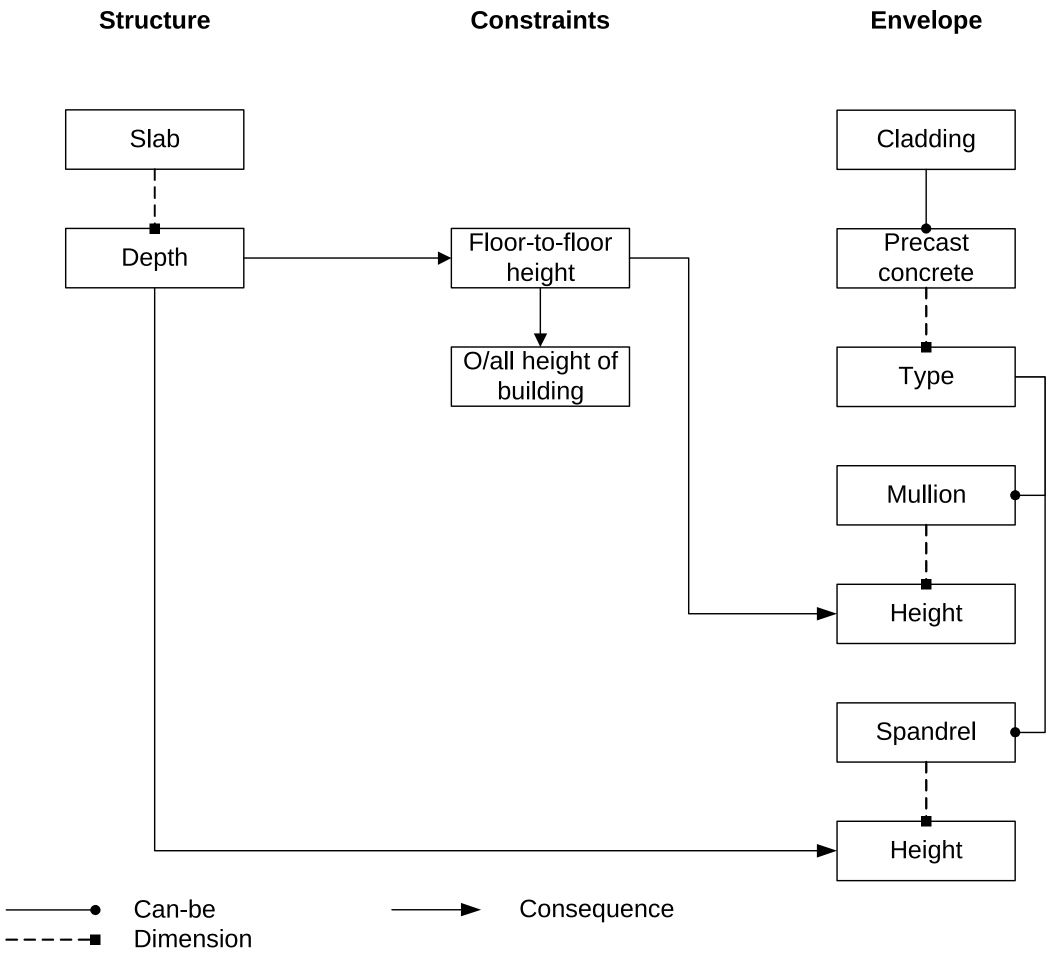

Figure 8: Sub-net 2 - Structures Dimensions

Sub-net 3: Fixing Decisions - (See Figure 9)
Cleats are usually preferred however the choice of a base-supported panel gives greater preference to the choice of dowels. With base supported panels any type of fixing is possible while dowels are not used with top hung panels. The choice of in-situ structure slab causes specific tolerance issues and gives greater preference to the choice of cleat as a fixing for the

pre-cast concrete cladding. The choice of cleats permits the choice between channels, cast-in-sockets, drilled-in-sockets or expanding sleeves as a method of fixing at the edge of the structural slab. Cast-in channels are usually the preferred fixing method at the edge of the slap however by choosing dowels the fixing method at the edge of the slab should be pockets; which is less preferred option.

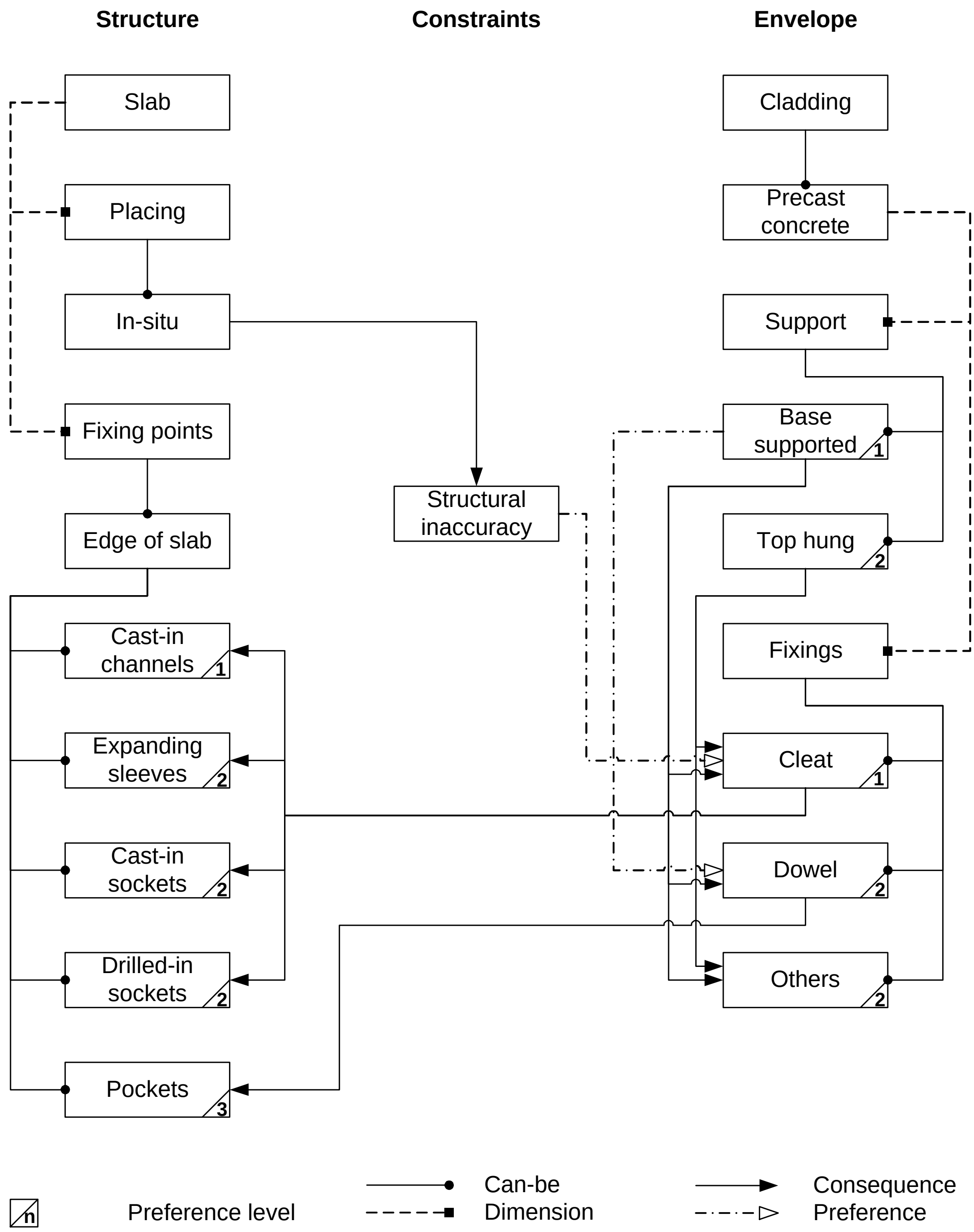

Figure 9: Sub-net 3 - Fixing Decisions

CONCLUSION

A generic model of the design process can be developed and presented in a KBE form. The knowledge acquisition must be done in a careful and thorough way. An approach based on the identification of the deliverables of the design process enables a bottom up model to be built. Constraints when certain technological choices are made allow the model to adjust to the specific situation. Additionally preferences for particular solution can be provided to guide the user as to the best practice solution. If this approach were to be developed further into a knowledge base for all technologies it would require the definition of the design elements of the domains and the constraints that link these design elements to each other. The knowledge base could be structured into the following modules:

i) The element definition modules. Each module in this section defines the design elements of a specific domain in the construction industry, such as the structure elements definition module.

ii) The specific domain nets modules: Each module defines the ECE sub-nets generated by the interrelationships of the specific domain elements.

iii) The global nets module, which defines the ECE sub-nets generated by the interrelationships of design elements across domains.

iv) The design context module, where the user can consult detailed information about the design considerations relevant to an ECE sub-net supported by graphics.

A knowledge base built in this way can offer proactive advice as to preferred design options when certain choices either have been made or are about to be made.

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MANAGING A RESPONSIVE ARCHITECTURE BY INITIAL DETAIL DESIGN

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Abstract
How can we make it possible that people can achieve their needs and wishes in the buildings they live and work in, day in day out, year in year out? People change, requirements change, for the same people, for different people… But people also have constant needs, physical, psychological and spiritual. The value for people of the built (and unbuilt) environment depends on the degree of change/responsiveness on one hand and the safeguarding of a constancy of wellbeing such as health, comfort and security on the other hand. One of the most essential factors considering management of the potential of the built environment regarding safeguarding and responsiveness is the joint/the detail considering its functions of meeting, fixing and sealing. We can observe the joint as a Mediator, Creator and Informator. We can investigate each of these aspects and detect how they determine the degree of safeguarding and responsiveness during the lifetime of parts or the whole building.

Keywords: Design management, Detail design, Value

INTRODUCTION
One of the most notable characteristics of our time is change, transformation. This change is accelerating because of the effect of media, technology and therefore our way of thinking, thinking about the individual, thinking about the group, society as a whole. There is a constant process of defining one's position between the individual and the group. We see this in fashion: on one hand distinguishing oneself and on the other hand seeking the "group" look, wanting to belong to a certain group, class, stream. This can be hard work to keep up, because the speed of change in fashion is high, consequently the lifetimes of clothes is very short, wardrobes keep shifting. If clothes are our second skin, how does a building, being our third skin, relate to this phenomenon of change?

In architecture today we see that in the time span between the first sketches and the building execution functions can change several times due to a changing market, economy. Even new developments in building components could call for different choices: in a three-year period a lot can happen. In that period fashion has changed at least six times. Building cannot cope with that tempo, at least not in the same manner. We could also draw the common analogy with automobiles considering change and distinction.

Change in building is not something you do on a Monday morning. Why is this the case? Do we need change in building? How can buildings change? To get an idea about answers to these and other questions we must look more closely at the nature of building in relation to ourselves and to our environment. We can distinguish three ways of looking at a building:

- The building as a mediating phenomenon between inside and outside: the MEDIATOR
- The building as a technological achievement of materials and parts assembled to a whole: the CREATOR
- The building as information carrier, having meaning and giving meaning: the INFORMATOR.

WINDOW-FRAME AS CASE

Let us take a look at a specific part of a building. First we build a wall, then we make a hole in it: the window. Let us examine the window as a case to find out where we stand considering details/joints in building. Why joints? If we are talking about change in building would it not be obvious to first focus on joints where building components meet, are fixed together and seal?

Like the wall the window is a MEDIATOR between inside and outside, controlling the passage of various factors, People have requirements in this sense, requirements that are on one hand constant and on the other hand variable. Different people inhabit the same building. Outside conditions vary as a rule. For the factors Light, Warmth, Air, Moisture, Sound, View, Field / Radiation, Minerals (e.g. dust), Plants (e.g. pollen), Animals (e.g. flies) and People the wall, the window and their joints must regulate to a certain degree the passage from inside to outside and vice versa. In addition these requirements change constantly. These changes are different for the various factors: more Air, less Warmth, more Light, less View etc.

Have we defined requirements in this sense, so thoroughly? Are we so conscious of these requirements? Wouldn't our health benefit by complying with these requirements?
In the way these requirements have been presented here we all know that we do not achieve performances accordingly by our buildings. Is the reason to be found in the limitations of our own building technology? Or are there other reasons that have nothing to do with technological abilities? Let us look into that aspect.

In the way the wall and the window performs as a Mediator depends on the aspect of being a CREATOR of means to achieve this (in addition to the joint as INFORMATOR as we shall see further on): the Execution of building parts, jointing parts and jointing materials, their assembly; during use the Durability and extending lifetimes by possible Maintenance. The questions in this sense are various:

- Which materials do we choose for which part?
- Why do we choose certain materials for certain parts?
- Which shape, size and position do these parts have in the whole?
- Which processes are used for acquiring these materials and producing the morphology of parts and whole?

In other words: what is the state of the art in building terms? Are we doing the best we can economically? Are we doing the best we can technologically at the moment? These are two different questions at the moment, but actually they should not be.

The present situation
What is the situation now? When looking at windows we must first of all point out the fact that the window as a phenomenon exists worldwide. This may seem very obvious, but is it really? Let us take a quick scan of window development in the Netherlands over the last century. A century ago a window-frame was a very simply profiled piece of wood with a single rabbet for the window and a butt joint with the adjoining wall. In time performance requirements have continually increased in favour of health and comfort. The solution in building terms has been in general to add parts and materials to about the same basic window-frame. For every additional requirement you seemed to get an additional part or material. This development has resulted in the present aggregation of main components, jointing parts and jointing materials:

- Sandlimestone blocks as inner-leaf + mortar
- Interior lintel + mortar
- Window-frame → wood + glue + paint
- Window → wood + glue + paint + rubber gasket
- Window-pane → glass + interior gasket + interior sealant
- + exterior gasket + exterior sealant
- + exterior wooden trim + nails
- Metal fastenings + plugs + screws
- Plastic flashing + lead or vinyl flashing
- Mineral wool cavity insulation
- Brick wall as outer-leaf
- Exterior lintel + mortar
- Ceramic or stone exterior subsill + mortar
- Sealant (gasket or foam) between inner-leaf and window-frame
- Metal corner beads + interior plaster
- Ceramic or stone interior subsill + mortar
- Interior wooden trim + nails
- Paint on all wooden parts

Depending on how you distinguish, the list represents a total of about 30 parts / materials. The underlined parts are considered the main components; the rest are jointing parts and jointing materials (see A Typology of Joints, Olie, 1996 for further elaboration).

Consequences
What does this all mean for the wall, the window and their joints as Mediator, complying with ever changing requirements and conditions focussing on health, comfort and safety? This means the Mediator must be adaptable, responsive in its performance of regulating the passage of Light, Warmth, Air, Moisture, Sound, View, Field / Radiation, Minerals (e.g. dust), Plants (e.g. pollen), Animals (e.g. flies) and People.

What does this mean for the wall, the window and their joints as Creator, considering the performance requirements as Mediator? When we look at the present development of the window we see that the number of parts and materials is increasing. This increasing number means an increasing risk of building failures, despite the fact of partial aggregations of parts meaning factory assembly. Controlling this process puts a high pressure on management of communication, logistics, labour, working conditions, regulations etc.

We can also look at the kinds of parts and materials, what are they made of, are they toxic, harmful for people and environment, do they appeal to us, do they support our well-being? The main components are relatively acceptable, but the majority of the jointing parts and jointing materials are distinctly less agreeable (lead, plastics, paints, glue, foam), all fulfilling the functions of fixing and sealing. In this sense we must be aware of the fact that a building becomes part of our total living environment, initially meant to support well-being. So besides an interior and an exterior we also have a building to consider, the Creator as means to achieve the performance of Mediator.
On a larger scale we have the question of where do these materials come from, what does the processing leave behind considering waste, pollution and landscape?
Our building technology, especially our joints reflect our society (let me see a typical joint and I will tell you what kind of people they are), the way we think; the way we organise production, labour; the values we have; our care for the short term, for the long term, for ourselves , for others, for our environment,…

When we look at windows at present we see a thinking in terms of distinct products, we see simplistic production processes, we see a lack of craftsmanship, of care, we see a lack of possibility to exchange parts, we see a lack of sufficient responsiveness to change, we see the lack of appropriate simplicity, we see the lack of an integral approach, instead we see complications, we see a lot of management, we see a lot of maintenance, …things we never asked for (except for the companies that thrive by this situation)!

The fact that we see or don't see things has to do with, in this case, the window as INFORMATOR. Do we experience the relationship between the aspect of MEDIATOR and the aspect of CREATOR in the wall, the window-frame? This relationship is what the aspect of INFORMATOR is all about according to the definitions used here.
The question here is: do we really "know" what a window is, what its meaning is, does the window "reflect" ourselves ("*…to what extent do I feel a personal relationship with it? To what extent does it serve as a pool in which I can see my dreams, sorrows, the beauty of the world?…*" Christopher Alexander in "The Nature of Order", 2004).

The factors Material (colour, texture, smell, feel, taste), Image and Control (changing material and morphology of the joint) are essential to help us to understand the window. What has happened actually is that the window as such has become a symbol. This is a very natural phenomenon in perception by people: we always are trying to grasp the meaning of our environment, naming them and building up a collection of images. But these images tend to be quite fixed in the minds of people.
Therefore the symbolic meaning can be just as strong or even stronger than the functional meaning; this also accounts for the professionals in building! This "symbolism" is responsible for stagnation of innovation in building (There is another reason for this that lies in the realm of norms and regulations, but this is outside the scope of this paper).
People rely on images and symbols in order to make sense of their world, but intrinsic

knowledge of "why" (MEDIATOR) and "how" (CREATOR) is conditional to really understand "what" (INFORMATOR). To put it the other way around: if you want to know "what" something really is, then you must ask yourself "why" and "how" it turned out this way!

This points out the importance of education, teaching young generations to really look at their environment, scrutinize, ask questions, explain, and eventually suggest, propose improvements, especially dealing with the phenomenon of change. In the book "Principles of Architectural Detailing" (Emmitt, Olie & Schmid, 2004) the authors make an effort to encourage students (and other building agents) to think from first principles. This should help in freeing younger generations to shed the stifling effect of a conservative "symbolism", and to get on with true innovation. At the moment there is a strong pull of consumers determining the market. This seems to be allright and sounds very serviceable when mouthed by developers, but as yet the professional agents in building must take their responsibility and interpret consumers wishes in the right way.

GUIDELINES FOR FUTURE DEVELOPMENTS

Let us try to sum up guidelines or promising directions for the development of joints in relationship to "change" without losing sight of the safeguarding of constant qualities such as comfort, protection and inspiring living environments (physical, psychological and spiritual health).

Considering the MEDIATOR aspect let us aim for the ideal situation that simultaneousness and selective passage of the various factors in varying degrees is possible. These performance requirements must be made explicit and could have the format of a matrix showing the various scenarios.

Considering the CREATOR aspect the following design guidelines could be promising in favour of responsiveness to change and in favour of management:

<u>Develop windows as a multi-layered component.</u>

When this principle of a multi-layered component becomes a well established system having an open-endedness that lends itself to be simply added to or changed, then this takes the pressure off managing to comply with the various scenarios the Mediator can demand.

<u>Minimize the number of jointing materials and jointing parts.</u>

The less parts there are the less there is to manage. Clustering parts furthermore eases management.

<u>Develop a universal, modular joint-face for all parts.</u>

If all parts are interchangeable like LEGO, then the advantage for building erection and later building changes is enormous. This would also give the possibility of selecting building components of specific manufacturers at the last moment.

<u>Strive for independent assembly and disassembly sequences of parts.</u>

If this is achieved, then you never get stuck when a part cannot be delivered on time or that a part cannot be replaced without disassembly of a number of other parts.

The complexity should be in the morphology of parts.
Complex parts / simple joints is more favourable for management than simple parts / complex joints (see the example of the present day window). Complex parts are made in a controlled way (CAD-CAM) in factories, whereas joints are eventually made on site with varying weather and execution conditions, and with less skilled labour as is the situation at the moment.

Strive for loose-fit, rough joints and surfaces.
Tight-fitted, sharp, smooth solutions cost a fortune because of the time and labour spent on them. The management of this is considerably underestimated!

Strive for maintenance-free components and joints.
Maintenance is a very sensitive issue, especially for the owner/user, because it costs money, that could otherwise be spent on desired changes in time.

Link durability of parts to expected lifetimes.
This point is not always that consciously considered. It could lead to cheaper building, thereby saving money for future adaptations.

Considering the INFORMATOR aspect all that can be said for the moment is that time will tell! By definition here there is no a priori Material or Image! Material and Image result from the relationship between MEDIATOR and CREATOR. Of course we have reliable knowledge from the past, bur otherwise new knowledge and insight will and should result in new Materials (?) and certainly Images, along with new ways of Control, especially considering a much wider range of possibilities of change.

(Some of these guidelines have been proposed or confirmed at the international workshop Detail Design in Architecture 4, June 2005, Velp, The Netherlands)

RESPONSIVENESS AND MANAGEMENT: CONCLUSION
It is very common, even mandatory, that architects/designers develop concepts of buildings, neighbourhoods and cities. They are even expected to develop a number of variants for the sake of discussion and choice. Why does this not happen with joints/details? Because the details have already been developed and are very conveniently bundled in reference books…or so we think!

The design approach should be integral, acknowledging the phenomenon of change/adaptation. This would call for a generic built environment. The design method should be comparably generic being a procedure of definite design steps revealing the unfolding process leading to solution principles that have the potential for allowing change, especially during the lifetime of the building. In this sense the building becomes an “organism” capable of reacting to change in requirements and/or to environmental conditions. In the book “Principles of Architectural Detailing” a design procedure of “9+1 steps" is proposed. In these steps aspects and factors are made explicit, encouraging communication and discussion. Decisions can be made more consciously as a team. The guidelines mentioned above are more or less incorporated in this design procedure.

In 1974 there was the "shirt-sleeve session" at M.I.T. called "The Responsive House", having participants with their approaches ranging from Sim van der Ryn (representing the handicraft approach) to Nicholas Negroponte (representing the computer as intelligent environment). John Habraken had written his "Supports, an alternative to mass housing" in 1961 (English version 1972) in which he propagated responsiveness in housing. Where do we stand now thirty years later on the topic of change and responsiveness? We have always kept talking about it, but the culture of building at the moment is one of trying to avoid change, because this disrupts intended processes. We tend to think that it costs more; yes maybe on the short term, but surely not in the long run.

The built environment should reflect us, people as we really are, as a community, as individuals, ever changing in the sense of evolving, but always needing the basic "water" to drink. We must work and experiment with responsive built environments and recognize the joint as a key to achieve this. "Change" will be a positive phenomenon to manage in building.

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MANAGING MULTI-ARCHITECT COLLABORATIVE DESIGN CONCEPTION

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Abstract
This paper describes a PhD research on design management that addresses the collaborative design conception by multiple top architects in large and complex building projects. The research studies four actual cases in the Netherlands, namely De Resident in The Hague, Nieuw Stadshart in Almere, Oosterdokseiland and Mahler4 in Amsterdam. The research finds that current project management on design employs a variety of methods and instruments to coordinate the tasks and information, and optimises the programme and outcomes; but leaves out the idea generation as the 'black box activity' by the designers. As close collaboration in design conception has become a necessity, more interaction between the designers' creative processes is essential. To fill in the knowledge gap, the research develops a new framework centred at social-psychological approach to initiate and guide collective designing. The framework establishes the common ground between design and management, and proposes that managing multi-architect collaborative designing requires the managers to design the cognitive, social, and project frames of the architects. The framework is based on multidisciplinary scientific foundation and seeks to integrate the human approach to the existing systematic-rational project management approach. The potential practical implications of the new framework are illustrated through case studies. The scientific quality of the research is to be assessed using the measures applied for research associated with design, i.e. credibility, transferability, dependability, and confirmability. The research findings are to be practically validated using a large case study.

Keywords: Complex project, design conception, design management, framework, multi-architect collaboration.

INTRODUCTION

This paper describes PhD research that focuses on the collaboration between multiple top architects during the design conception. Design conception is a crucial activity that marks the beginning of urban and architectural design process. It is relatively short compared to the total project course, but it is very important to lay down the principal design concepts and decisions for the whole project. In design conception, the architects play the key role in direct consultation with the stakeholders and other specialists. Multi-architect collaborative design conception has recently become a trend around the globe as many high-profile design teams have emerged to take on large and complex architectural projects. Yang (2004) states that singular glory is a thing of the past; architectural firms, big and small, young and established, independent and corporate, are collaborating to create new design models, in project and in practice. This has consequently raised an urgent need for an innovative design management approach.

Design management has become one of the key factors to innovate the disciplines or urban and architectural design, but is a relatively new knowledge field in architecture. Current approaches are fragmented and largely experimental and literature on managing multi-architect collaborative design conception is scarce. Hitherto the understanding about the essence of the problem and the way to tackle it is very limited, thus research on this subject is timely and important for both professionals and academics.

This research aims at providing the building professionals in charge of supervising and leading the design team with the insight into the real situation and core problem, and enabling them to take innovative and rigorous approach for managing multi-architect collaborative design conception. The final deliverable of this research is a new conceptual framework which features a new paradigm, innovative design management activities, and examples of the potential implication. In general, a framework clarifies the fundamental understanding and the general point of reference and can be distinguised from a tool or guideline. These are necessary to prepare more detailed sets of instruments and lists of recommendations to be applied on specific situations. The new framework is expected to provide the professionals with clarification, comprehensive understanding, new perspectives, and new mindset towards the real-world situation. To achieve the general aim, this research has three interrelated objectives to be translated into research steps. The first objective is to carry out an empirical study to describe the real practice and to identify the problem and the knowledge gap. The second is to fill in the knowledge gap by introducing new paradigm and conceptual framework for managing multi-architect design conception. This is achieved after consolidating the existing knowledge of design management in architecture and transferring relevant knowledge and best practices from the other disciplines. The third objective is to indicate how the framework –which fills in the knowledge gap– can be coherently linked to the existing design management approaches, and to illustrate the potential practical implications of the new framework.

The practice of multi-architect collaborative design conception is complex and comprises many interdependent issues and factors, which cannot be isolated or understood separately. Therefore, this research needs to adopt a comprehensive and holistic approach. As qualitative research, it examines the phenomenon of collaborative design conception in its actual setting and the meaning people bring to it. It stresses the socially constructed nature of reality and uses constructivist as its interpretive paradigm. It generates knowledge based on different personal reconstructions of the phenomenon. The researcher's voice is that of a 'passionate participant' actively engaged in facilitating people's interpretations of the phenomenon from multiple perspectives (Denzin et al, 2000; Miles et al, 1994).

CASE STUDIES AND PROBLEM ANALYSIS

The empirical study for exploration and description is carried out by studying four recent cases of multi-architect project in the Netherlands, namely: De Resident in The Hague, Nieuw Stadshart in Almere, Mahler4 and Oosterdokseiland in Amsterdam (Sebastian, 2003a). Various top architects have worked on the design of the projects, e.g. Michael Graves, Cesar Pelli, Rob Krier, Sjoerd Soeters, Rem Koolhaas, Christian de Portzamparc, Rafael Vinoly, Toyo Ito, Jo Coenen, Erick van Egeraat, and Frits van Dongen. The projects are considered as ultimately relevant cases for research on design management in architecture. Since these projects are at the highest level of significance and complexity, they may address various issues and difficulties related to collaborative designing. The analyses and conclusions of the research on these projects would serve as valuable lesson for other projects. Besides, these projects match the PhD candidate’s professional experience, personal interest, knowledge, and network that support the data collection and analysis. The empirical research uses cross-case analysis over the project content and the design process, the real complexity and the reference to complexity theories, and the existing attempts to manage collaborative design conception. The empirical research concludes the unique characteristics of multi-architect collaborative design conception, its essence and main aspects for design management, the current knowledge gap which calls for innovation, and the outline criteria for the new design management framework.

This research finds the unique characteristic of multi-architect collaborative design conception in the fact that the creative idea generation is not carried out individually, but takes a great deal of interaction between multiple architects, supported by multidisciplinary specialists, in the design team. Individual designs are enhanced in team discussions. The total design is achieved through consensus and teamwork, rather than combining individually developed design solutions. A multi-architect project is usually driven by the high ambition for realising rich architectural composition as well as the political and market demands for the high-profile urban projects. This research also finds that multi-architect collaborative design conception has to face multidimensional complexity. The technical complexity is due to the large scale, function mix, large investment, long period, sub-project interference, and low failure tolerance. The social complexity is due to the large number of participants, broad social importance of buildings, and close collaboration of designers. The design complexity is due to the unique nature of design problems, solutions, and actors. While the construction engineering excels in offering technical solutions, the social complexity has been escalating on the top of the technical one and significantly influences the design complexity.

The empirical research recognises that any attempt to manage design has to deal with three main aspects: design people, processes, and products, so-called the 3Ps. The research on multi-architect collaborative design conception considers design people as the architects, design processes as the creative activities performed by the architects, and design products as the creative solutions resulted from the ideas raised and elaborated by the architects. Other researchers also address the 3P aspects. Buchanan (2001) sees design as shaping the values and responsibilities, the world of actions, and the subjects. Otter and Prins (2001) consider that design has the constituent elements of people, processes, and objects. Hoskin (2004) mentioned that management could be viewed as organisation structure, process, and content. Regarding creativity, Badke-Schaub (2005) refers to the capabilities of the designers, to the process of designing, and to the outcomes.

The empirical research goes further to investigate how the current management practice deals with these 3P aspects. Traditionally, the design requirements for a large and complex urban project are divided into several design briefs for different architects, each containing specific project parts and design problems to be solved. Each architect is assigned to work on his design brief in accordance to the rigid design guidelines. He then creates the partial design at his own design firm. Afterwards, the partial design solutions are put together on the previously designed master plan while the integral technical solutions are developed. The ‘traditional’ project management on design conception focuses on the process and product aspects: management of the process by coordinating and facilitating tasks, information, and decision-making; and management on the products by optimising design programme and requirements, and integrating architectural and technical solutions.

This research observes that current project management practice concentrates on facilitating and supporting the design processes and products, but fails to attend to the designers in conceiving the design ideas. Current project management practice supplies the information, coordinates the tasks, and controls the outcomes, but regards the designer's creativity as a 'black box' for management. This is the current gap in practice.

As close collaboration between the designers is currently expected, more interaction between individual 'black boxes' has become essential. Complex problems can only be dealt with by a design group using different perspectives. Total harmony cannot simply be achieved by merging partial outputs at the end, but only by synthesising during the creative activity. Designers are engaged in dynamic consensus of competing values and cross-functional synthesis of various individual interpretations. There are few management attempts on the collective idea generation, but these are rather spontaneous based on the initiative and experience of some design leaders and not rigorous in their approach. Innovative approach of design management is needed to fill in the gap by managing the people aspect in multi-architect collaborative design conception.

A further look at the people aspect reveals the interplay of three working frames: the cognitive frame, social frame, and project frame (Badke-Schaub, 2005). On one hand, the development of design solution is considered as a unique cognitive part of the problem solving process, requiring methods of enlarging and limiting the search area. On the other hand, solution search is seen as a social process in the context of collaboration and communication, where group structure and group climate play an important role to achieve the desired synergy effects. The social process also implies the co-operative behaviour, which might also take account of the relationships between conscious and unconscious aspects of behaviour in the design team. In practice, as the designers come together to carry out a real building project, they work in the so-called project frame with actual project goals, visions, constraints, operations, and deliverables. The cognitive, social, and project frames do not pre-exist, cannot be standardised, and have to be customised to meet the project content and the characteristics of the project participants and organisations.

The empirical research also indicates the criteria of the framework needed for managing multi-architect collaborative design conception. First, the framework should be appropriate for large and complex architectural projects, which are fundamentally different from the small and simple ones. Second, the framework should not be a generic one, but should be customisable to fit different projects and situations. Third, the framework should fill in the gap by addressing the people aspect. It should integrate human approach in design management with the technical-rational approach in project management. Fourth and last, the framework should view design management as a participative role in designing rather than an authoritative function in the project structure. Design management should be exercised in consultative rather than instructive way. In this capacity, it acts more as a peer rather than a superior.

LITERATURE REVIEW

State-of-the-art of design management literature in architecture was reviewed and relevant theories and best practices also sought from other disciplines. The literature research categorises the state-of-the-art of design management in architecture into several approaches, namely: engineering-instrumental approach, design-methodological approach, value-performance-and-quality measure approach, systematic decision-making approach, and organisational-protocol approach. The preceding paper by Sebastian (2004) reviews the work of Colin Gray, Stephen Emmitt, Matthijs Prins, Glenn Ballard, Laurie Koskela, Teake de Jong, Peter-Paul van Loon, Kerry London, Alijd van Doorn, and Gebhart Friedl.

The engineering-instrumental approach mainly considers a design process as a rational problem solving mechanism. It includes methods, tools, and techniques to coordinate design tasks and information. It has three dimensions: programming facilities, constructional issues, and inter-agency coordination. It employs the systems thinking to take out the parts, which can be well defined, and solve them separately. It extends to modelling of the multidisciplinary building design process as well as (re)designing the process. The design-methodological approach believes that certain design protocols facilitating empirical and logical knowledge can guide the design activities. It sees various design processes as an interplay of several methods, and provides transparent and systematically structured encyclopaedia of scholarly methods to assist an individual architect to access and point out methodological components during his design study or research.

The value, performance, and quality measure approach asserts that the most important mission of design is to produce objects that are able to meet the aesthetic and functional expectations in use, as well as the economical and technical requirements in production. Some research emphasises the role of design management for value creation for the stakeholders and project participants, while other research concentrates on the achievement of building quality especially in terms of architectural technology. The systematic decision-making approach investigates ways to optimise the design decision-making process using mathematical calculations for quantification of design decisions. This approach aims at complex multi-actor decision-making processes by measuring the alternative solutions against the parameters assigned on the parties' requirements and influencing conditions. The organisational-protocol approach deals with the management of design office and the relationship between an architectural firm and the other building parties. The office management runs the organisation, directs the design production line, leads the office and project administration, and supervises the contractual relationships with other parties. The management of inter-organisational relationship applies on design briefing and design contract management.

Critical appraisal of these approaches finds that the state-of-the-art of design management in architecture has not penetrated the core of multi-architect collaborative design conception, which is the interactive and collective idea generation. The existing research emphasises the design processes and products. The people aspect is addressed in formal, structured, and systematic ways, which are indirect to the creative activity by the designers. Thus, the same knowledge gap as in the practice seems to appear also in the academic world of architecture.

In order to fill in the knowledge gap, the literature research looks for relevant theories from other disciplines. These theories should address the cognitive, social, and project frames of the designers in collaborative design conception. The research goes over the theories from thinking to action, and from individuals to groups. It covers the description of the architect's thinking, the personal and organisational knowledge, the group behaviour and creativity, and the reflective practice. The preceding paper by Sebastian (2003b) reviews the work of Donald Schön, Ronald Hamel, Omer Akin, Ikujiro Nonaka, Michael Polanyi, Laurie Mullins, Christopher Barlow, Helga Hohn, Rianne Valkenburg, and Isabelle Reymen.

Hamel observes a number of experienced architects at work and describes their thinking process in a cognitive-psychological model. His model proves that what seems to be creative coincidence during the design process is not necessarily a sign of randomness or chaos. The components of such creative process actually relate and interact with each other in certain ways. These are strongly associated with personal experience and subjective judgment in perceiving, reframing, and analysing the problems, as well as synthesising and shaping the design solutions. From Hamel's research, design management can learn to recognise such cognitive process in order to channel the cognitive patterns of multiple architects in collaborative design conception. Nonaka et al. discuss the personal and organisational knowledge creation. An important knowledge dimension is the tacit knowledge, defined by Polanyi as person-attached knowledge, which can be understood by its being-in-use and can be learned by its being-performed. By this, design management is reminded to pay attention both to the explicit knowledge which can be transferred to the design team through documents and protocols, as well as to the tacit knowledge which can only be shared through social interaction and coaching.

A great deal of research has been done on group dynamics that studies the behaviour of people as they interact within the organisational setting. Concerning the group creativity, Barlow presents a deliberate insight model which describes the creativity in a group as an insight shift –which is often triggered by the idea of the other group members– towards the better understanding of the problem and solution. Being aware of the importance of the insight shift in a group, design management can learn from Hohn's research about combining generative and focusing modes of leadership for creative teamwork. Schön explains how a designer learns from knowing-in-action and works through reflection-in-action. Designing is a reflective conversation when the designer shapes the situation in accordance to his initial appreciation of it, the situation 'talks back', and the designer responds to its 'back-talk'. Akin supports this by saying that the deterministic relationship that exists between the problem description and its solution is dialectic one. Valkenburg extends this by stating that the designers in a creative group can also reflect on each other's thinking and working process in the so-called reflection-in-collaboration. For design management, reflective practice is essential because it provides the way to place the design cognition and knowledge into the actions by individuals and groups. Design management can make use of some methods, such as reflective practicum, structured reflection in design session, and reflective design teamwork.

NEW PARADIGM AND CONCEPTUAL FRAMEWORK

A common ground and joint scientific paradigm between design and management are essential to develop design management. As long as people perceive design and management standing on two poles apart, it is impossible to build on design management. This research seeks to present the interface between design and management. Allinson (1997) and Tunstall (2000) have attempted to bring project management methods and techniques to the architects for more effective design process. This research goes deeper to examine whether the two activities fundamentally have shared nature; to prove that management can find its nature in design and vice versa. It draws upon some aspects of the work of Vitruvius, Peter Drucker, Herbert Simon, John Christopher Jones, Thomas Kuhn, Louis Bucciarelli, and Richard Buchanan.

Design and management are knowledge intensive human activities, which work with and within uncertain situations, to deliberately initiate and devise creative processes for shaping more desirable reality (Sebastian, 2005a). Within this term of reference, one should understand that design management is not only problem solving, but also problem-finding. It is not the steering of activities and resources towards the static, pre-defined goals or requirements, but the critical examination and reformulation of both the requirements and solutions. It is not the attempt to find a single best solution (since there is probably no single best solution in design), but the reflection that the searching itself could be most important. It is not the one-way journey of making decisions to narrow down the possibilities on the course of the project, but the iterative process to continuously review and refine the possibilities. Furthermore, with respect to the people aspect, and in relation to the cognitive, social, and project frames of the designers; managing multi-architect collaborative design conception finds its scientific paradigm in the social sciences. Bucciarelli and Drucker stress that design and management are social processes. Both in practice and science there is a shift to human approach. All four cases show the evidence of the significance of the social interaction, respect, trust, and commitment in the design group, and the charismatic leadership by the architect supervisors. In science philosophy, there is 'an evolution' from systematic-rational to social-reflective paradigm. There is a revival of the human factor, with its unique cognitive facilities, as the focal point in design and management. Buchanan (2001) notes this as a fundamental shift in the intellectual arts that we employ to explore design in practice and research. The early theories of design found expression in grammars and logics of design thinking, but the new ones find expression in rhetoric and dialectic.

Based on these findings, this research introduces three propositions of the new framework for managing multi-architect collaborative design conception. First, managing resembles designing, if the two activities are interpreted as human practices. Design must be seen broader than creating buildings or artefacts; design product can be about anything, e.g. organisation, process, communication, or service. Second, managing contains the art of designing, as design attitude and thinking are essential for managers. Designing and managing are inescapably intertwined, so bringing the art of design into the practice of management is important. Design thinking and design attitude are crucially important for managers, but remain overlooked in much management practice and science. Design thinking is believed to be very useful if it is applied to a widening circle of human problems that are no longer adequately addressed by traditional methods and practices. Design attitude views each project as an opportunity for invention that includes a questioning of basic assumptions and priority for innovation (Boland, 2004).

The third proposition figures a manager as someone with design competence who actually performs designing; or in other words, managing-by-designing. This is in line with Simon (1969) and Schön (1983) who see a manager as a form-giver who shapes organisations and economic processes. In a certain situation, a manager is like a technician whose practice consists of applying principles and methods derived from management science to solve organisational problems. In another situation, a manager is expected to be like a craftsman, a designer, and a practitioner of art-of-managing that cannot be reduced only to explicit rules.

Managing works through designing, as the managers are expected to design new cognitive, social, and project frames to encourage the interaction between individual 'black boxes' to allow one's creativity to be stimulated and enhanced by other members of the design team. Managing by designing the cognitive frame means developing and configuring heuristic devices to stimulate and facilitate the generation of innovative ideas. Managing by designing the social frame means creating the environment which fosters positive group behaviour for collective creativity. Managing by designing the project frame deals with the goals, visions, constraints, resources, and outcomes of a real architectural project on which the design team is working.

The framework elaborates certain 'design activities' by the manager. Designing the cognitive frame can be carried out, for instance, by diagramming and sketching to enhance design and management cognition; developing and composing meta-models, metaphors, and analogies to engage shared understanding; and activating expert intuitive judgement to support design decision-making. Designing the social frame can be done, for example, by setting up design studio-like working environment; team building for architects; and assuring dedicated and highly motivated effort. Designing the project frame could comprise such activities as reinventing goal and vision; re-construing and reframing constraints; and shaping and synthesising solutions.

ILLUSTRATION OF POTENTIAL PRACTICAL IMPLICATIONS

This research demonstrates the potential implication of the new framework through several real situations in the case projects. It finds that a few experienced professionals have exercised some innovative approaches in the framework. However, the application takes place rather spontaneously, unconsciously, irregularly, and incompletely. This research describes how the rigorous application of the framework could bring significant improvement. It illustrates the coherent application of human and engineering approaches depending to the characteristics of the project and participants. An example of managing by designing the cognitive frame can be found in the Oosterdokseiland project. Usually, sketches are used by the architect to describe his interpretation of the client's requirement. In Oosterdokseiland, sketches are also used by the manager to design the programme in this project to explore, set-up, and elaborate the references and requirements. As a building designer, the PhD candidate has sat down with the manager of the client organisation to sketch all project strategies and prepare the design programme. One of the architects, Jo Coenen, says that by doing sketching together with the client, both parties can try to understand the expectations and possibilities better.

Another example related to designing the cognitive frame is found in the design workshop, as the creative “aha!” can be triggered by ideas from diverse people. For instance, the support staffs that are looking at the problems from different –yet complimentary– perspectives can spark the ingenuity of the architects. To encourage all participants to understand the design ideas and actively contribute to the discussion, broad vocabulary and means of representations are needed. In the Nieuw Stadshart project in Almere, the workshop participants are asked to take an imaginary walk through the to-be-designed urban spaces, and subsequently to express their feeling of the city (the meanings and perceptions of the urban spaces) using references to other familiar existing cities around the globe, metaphors, analogies, images, stories, and arguments. An example of managing by designing the social frame can be seen in the urban design atelier of the Zuidas/Mahler4 project wherein the urban designers, architects, and managers work together. In the atelier, the informal social atmosphere stimulates mutual dialogue and exchange of ideas between different designers and between the manager and the designer.

The social interaction in designing can become significant in the design team composed of members possessing complementary team roles and characteristics. Successful collaboration results in social contract when it is moral rather than contractual argument that turns the actors. One of the real examples of this is how group’s suggestion rather than management’s instruction has led Sjoerd Soeters changing and improving the design of Helicon building in De Resident project. The architect supervisor plays an important role as the social catalyst next to their task to evaluate and maintain the overall design quality. His role is harmonising the expertise and orchestrating the behaviour of the design group.

An example of managing by designing the project frame is instilling the integral design vision and altering the design goal to be opened to innovation during the design process. In the Nieuw Stadshart project in Almere, the urban vision is elaborated through close discussions between the master plan architects (OMA, represented by Rem Koolhaas and Floris Alkemade) and the clients. The clients critically examine the architects’ visions through technical-social-economical considerations of project realisation. After the master plan has been established, a Q-Team is set-up to develop and translate the vision together with the project architects through direct briefing and discussion.

In the Mahler4 project, the vision of Mahler4 is a part of the comprehensive urban development vision of Zuidas. This includes various urban issues, e.g. development plan, environment, infrastructure, mobility, economy, labour opportunity, leisure and culture, housing, and public facilities. To translate the vision into architectural design, a workshop involving all design actors and stakeholders is organised. In De Resident project, the vision is included in the “Design Guidelines LAVI-kavel” using architectural presentations. Thus, the guidelines are actually meant to share the design vision –such as block and building forms, spatial philosophy, and material and colour impression– rather than to impose strict rules for designing. The architects share and build on this vision during the design workshops.

Before applying the conceptual framework of managing-by-designing for multi-architect collaborative design conception, one needs to consider the preferred personal skills of the person in the design manager role. He must possess rich knowledge and experience of urban and architectural design, and the development and realisation process of large and complex projects. At the same time, he must master human relationship to fuse the sometimes-individualistic architects into a smoothly functioning design group. Having these two competencies in a good balance supports the professional integrity of the design manager. Some analogies can be used to illustrate this. Just like a top football team needs a top coach, a design group consisting top architects needs a top design manager with highly respected knowledge, experience, and charisma. Team leading, coordination, training, and consultation occur through personal and direct interactions between 'the coach' and 'the players' in the 'playing field'. The design manager also needs to combine rationality and passion, like in dance choreographing, which translates the passionate design talents into a more choreographed and staged process (Friedl, 2002). Moreover, He is like an orchestra conductor, whose role is to orchestrate various individual features and abilities to create a lively harmony. Conductors may not be able to play the instruments better than the orchestra members, but their value lies in their ability to bring the players together into a great performance.

In practice, the main targeted users, the architect supervisors, the managers, and the leading designers, can benefit from the new framework in the following ways. The architect supervisors possess rich knowledge and experience in urban and building design, and the personal quality as respected and highly credible senior professionals. However, the role of supervisor is new to many of them. The framework can inspire them to turn their design know-how to create and instil visions, give inspirations and guidelines to the design group, as well as clarifying their role in preparing and leading design workshops. The senior project managers usually have in mind numerous patterns of decision acquired from long experience in various complex situations. For decision making under uncertainties and lack of facts, the framework can point to the experts' intuitive judgement to fill the gap in systematic analysis. Designer's cognitive tools like sketching and diagramming may also be useful to explore and conceive management strategies. The leading designers can benefit from the framework that empowers them to be able to enhance their creativity through group processes. Teamwork can result in the improvement of individual and integral design.

The new conceptual framework for managing multi-architect collaborative design conception does not limit itself to the 'design activities' presented in this paper. The new framework demonstrates the way of thinking and identifies the main issues, but it can be enriched by non-exhaustive aspects and linkages whose complementary interrelationships are dependent to the situation in different projects. The new framework fills in the gap of managing the people aspect to build a coherent design management practice. Without the intention to generalise or standardise, this research presents an example to consider the coherence between managing the people aspect based on the new principle of managing-by-designing and the existing design management approaches (Figure 1). The cognitive activities in the project context can be supported by certain protocols, information, and coordination of tasks. The idea generation in the social context results in the design products that are designated for the stakeholders and communities with their specific goals and expectations. The collaboration in a real project takes place at an organisational system with its structure and procedure for operation and decision-making.

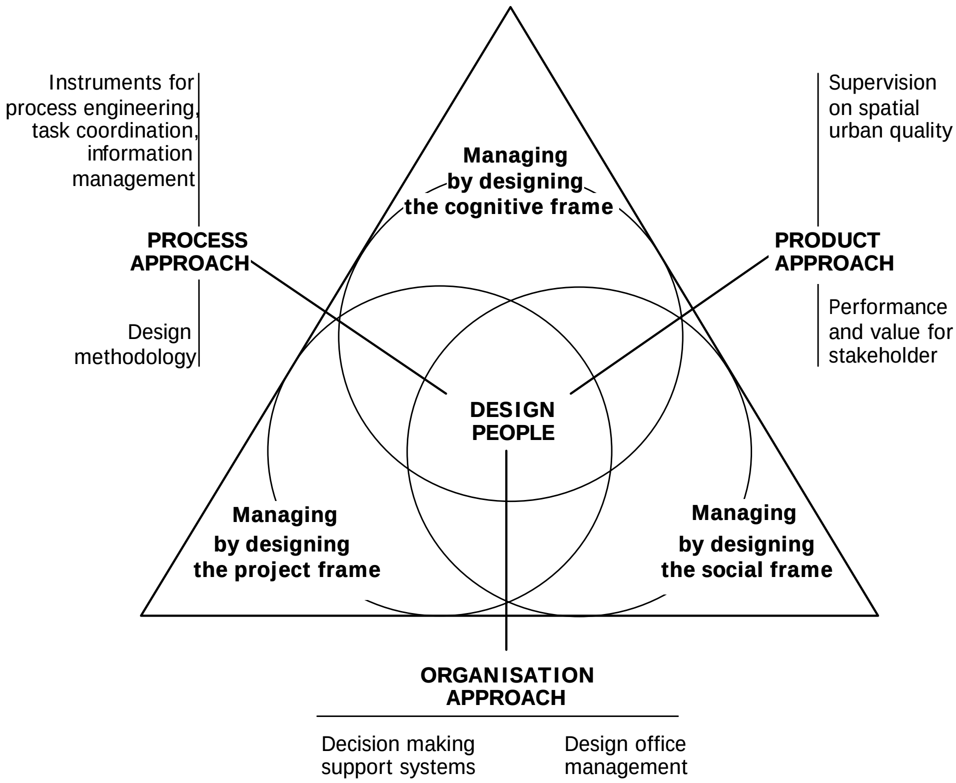

Figure 1:
An example to view managing the people aspect based on managing-by-designing in coherent relation with the existing design management approaches

VALIDATION AND CONCLUDING REMARKS

The assessment of the scientific quality of the research follows the notion by Groat and Wang (2002), Whitman (2003), and Sebastian (2005b). They argue that design process might be considered to be a form of research inquiry and that research activities associated with design should be assessed through different quality measures than those used to assess research in natural sciences. Groat and Wang address in a very helpful way the question of how research quality is maintained when a non natural science, non-positivist approach to research is adopted. They suggest that the social sciences offer well accepted research methods that might allow certain forms of design activity to be regarded as modes of research. In describing their model of research, they match the quality measures familiar to the positivist paradigm (such as validity, reliability, objectivity, and generalisability) with new measures of credibility, transferability, dependability, and confirmability. Thus, if a research activity associated with design is to be considered good quality research, it should aim to be credible, transferable, dependable, and confirmable. Credibility is a measure of the truth-value of research activity, in much the same way as validity measures the truth in the natural sciences. A research activity associated with design can be shown to be credible if it can be confirmed through something akin to triangulation, whereby a variety of sources and techniques are used to cross-check the research outcome. To achieve transferability, a sufficiently ‘thick’ description of the research activities and outcomes must be provided so that others can adequately assess the value of the research. To establish dependability, a research activity associated with design should establish an audit trail that documents all the processes by which data are collected, decisions are made, processes are followed, and outcomes are analysed and interpreted. Neutrality, ensured by the presence of objectivity in the natural sciences, is guaranteed in the research associated with design by establishing confirmability through transparency of activity and reflexivity on the part of the researcher.

For the practical validation of the research findings, a new case study will be used. Simulating design sessions involving top architects working on (fictive or real) complex project in order to test the research findings does not seem to be feasible in this PhD research. Therefore, this research would use an existing case whose design process has been well recorded in videos, lectures, and reports. These documentations reporting the workshop of different design teams are to be analysed to determine whether the new framework adequately addresses the main issues, and whether the proposed innovative approach is practically relevant for similar cases of multi-architect collaborative design conception.

The multi-architect collaborative design conception for the design competition of Ground Zero in New York would serve as a very relevant case study for validation. There is no doubt about the significance and complexity of the project, which has attracted many top architects to form the collaboration in various design teams. From hundreds of submissions, six teams have been selected to develop the “New WTC Proposals” in the period of September to December 2002. The selected teams, some containing several architects, planners, or firms, are as follows: the team of Richard Meier, Peter Eisenman, Charles Gwathmey, and Steven Holl; the United Architects, the collaboration between Reiser Umemoto, Foreign Office Architects, Greg Lynn FORM, Imaginary Forces, Kevin Kennon Architect, and UN Studio; the THINK team composed of Shigeru Ban, Frederic Schwartz, Ken Smith, Rafael Vinoly; the team of Skidmore Owings & Merrill with Field Operations, Tom Leader, Michael Maltzan, Neutelings Riedijk, and SANAA; Studio Daniel Libeskind; and Foster and Partners.

The framework serves as a conceptual basis and turning point to guide the practice through the process of integrating design competence into the management. It is also expected to expand the purview of design to include not only products, services, and experiences, but also the organisational means by which they are created and supported. The framework enriches the people’s views of design management by provoking a series of revealing insights regarding the social-psychological approach. It hopes to open new horizons for the science and practice of design management and presents guiding images for the future. The implementation of the framework is oriented towards progressive and fundamental improvement in the world of architectural design management, rather than one-time radical breakthrough.

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A BRIEFING APPROACH TO DUTCH SCHOOL DESIGN

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Abstract
The brief as a collection of general and specific requirements on a new design is frequently underrated by designers who tend to complain that many briefs are superfluous or that they impede creativity. Such criticism is unfortunately often founded. Nevertheless, the brief remains not only a binding specification but also a reference framework for design analysis, communication and guidance. The potential of the brief becomes apparent in new design problems designers may be unfamiliar with, such as the accommodation of secondary education in The Netherlands. Following fundamental pedagogical changes at the end of the twentieth century, Dutch schools are increasingly interested in experimenting with new, even experimental didactic approaches. The paper describes the development of a computer-mediated briefing approach for secondary education accommodation in The Netherlands that attempts to integrate all aspects without destroying their modularity into an information system capable of addressing different levels of abstraction. By coupling the integral brief to the design in the computer we can automate analyses of all related aspects at any given time. Analysis becomes a permanent yet unobtrusive activity that supports creativity and communication.

Keywords: Analysis, briefing, school buildings.

SPECIFICATION, ANALYSIS AND GUIDANCE

A design process should start with rich, structured information that helps identify primary goals, relevant aspects and specializations and provides criteria for design and building performance. The main hypothesis underlying this paper is that a prerequisite to the solution of a design problem is the analysis of use requirements in a way that (a) makes explicit the actual needs of activities to be accommodated in a building at a level of specificity that allows creative but focused designing, and (b) separates these needs from implicit assumptions derived from stereotypical attitudes and solutions.

The programmatic requirements are traditionally distributed into a number of complementary documents that specify behaviour and performance from different viewpoints relating to different disciplines or parties. Our alternative is to integrate all the information on the basis of a common structure (backbone), such as the list of activities to be accommodated in the new design. The programmatic requirements become properties and constraints of the spaces that accommodate these activities. Continuity, coupled to the comprehensiveness of the information and the availability of several abstraction levels in the resulting information system, facilitates the development of a responsive informational background for all actions and transactions concerning the design, evaluation and use of the built environment. Working with an integral design brief promotes the interaction with different parties including the one with clients and users.

EDUCATIONAL CHANGES IN THE NETHERLANDS

The development and stabilization of a building type is arguably the last stage in a process of evolution that transforms a set of new use requirements into a generic form. Reversely, the existence of a building type may also impose a restrictive framework that only allows a specific interpretation of use requirements, even when they deviate from the ones that relate to the evolution of the particular type. In other words, design innovation and performance may be stifled by the association of particular spatial and building arrangements with specific classes of activities. The problem lies in that architectural types tend to be static (or at least slowly evolving), while activities could change rapidly and in unexpected directions (i.e. revolutionary).

The current situation in Dutch secondary education is a clear case of this uncertain relationship between slow design evolution and rapid use revolution. Following patterns of change common to many European countries, secondary education in The Netherlands had been stabilized in the 1960's into a clearly instructivist system that related directly to a small number of basic types (Boersma et al., 1996). The basic type was the *corridor school*, a direct descendent of the model designed by the government in 1811 to improve the efficiency of school building. The main task for architecture then was to allow the teacher to have a permanent supervision over all the pupils simultaneously. In 1863 a new law made it possible to choose subjects and the basic building type of the government from 1811 was progressively transformed into the *corridor type*. To make it possible for different subjects to be accommodated in separate classrooms the main space of the model was divided into three separate rooms and connected with a corridor; the currently still used corridor school emerged.

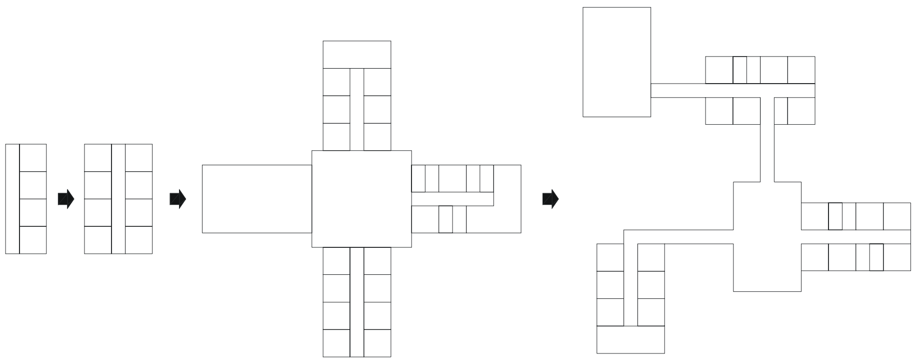

Figure 6. Typological evolution of school buildings in the Netherlands: (left to right) corridor, hall and pavilion types

The development of the *hall type* was a natural consequence. Further transformation of both the corridor and the hall types has lead to the *pavilion type*. A common characteristic of all three types is the presence of a large number of traditional classrooms (either connected by a corridor or a hall). This makes all three types predominantly appropriate for formal teaching, i.e. by a single teacher that lectures a group of students.
Of particular importance is the ability to recognize the topological structure of building types. The types described above have a clear topological basis, but this is seldom described explicitly. By making it explicit we are able to study relationships between

types and identify the type of a building not only in whole but also in part. The latter is crucial for the study of transformation, as it helps identify typologically hybrid solutions and partial mismatches with the spatial articulation of a building.

In the topological representation entities and relationships are represented in a graph (Steadman, 1976). This makes it possible to describe relationships and patterns in the spatial and building structure. The topological representation focuses on the spatial entities and access between them as the main relationship. The resulting access graph forms a basis for the description and analysis of spatial articulation at a higher abstraction level, as well as of dynamic aspects such as pedestrian circulation (Figure 7).

The topological representation of a corridor school makes explicit the sequential spatial structure of this type. Spaces are positioned on either one or on both sides of the circulation space. The exceptions like entrance and gymnastics are visible as separate wings shoved into the building. The topology of these special wings can differ from the rest of the school. The topological structure of the hall school shows us that the different wings are actually variations of this corridor type. These wings are all connected by a central hall. The pavilions in the pavilion school are easy to recognise and can all have their own structure. These individual pavilions are variations of the corridor type too. The comparison of the three topological structures reveals that on a local level the corridor school forms a clear prototype. Practically all school buildings consist of a number of identical groups of classrooms or specialized spaces. The main difference between the corridor type and the other two is that in a corridor school these groups are arranged sequentially, while in the others they form separate clusters (Koutamanis and Steijns, 2003).

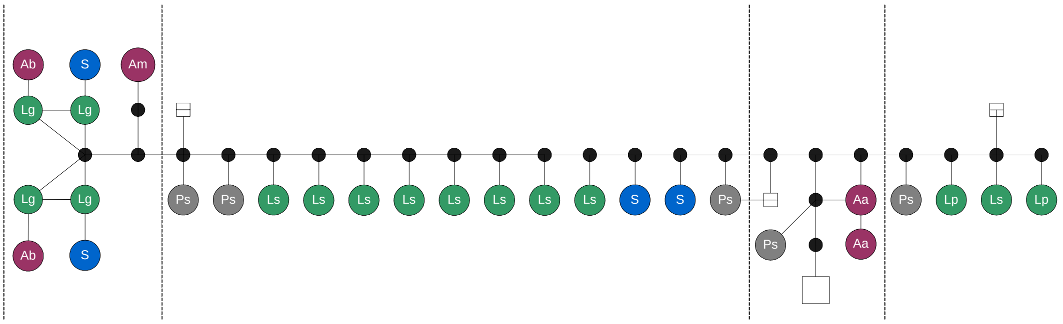

Figure 7. Topological representation of the corridor type

The basic building block in all school types is the conventional classroom, a space virtually unchanged from its Victorian ancestors. The high ceilings, the extensive fenestration and the arrangement of pupils as a more or less passive audience to a single teacher are features that refer to a mix of good intentions and humanistic principles with arbitrary, mostly metaphorical architectural interpretations (the healing power of sunlight and fresh air – clearly a direct reaction to the slums of the time) and authoritarian approaches to knowledge dissemination that befitted the social structure of the period. This mix made the classroom a constant in school architecture for almost two centuries, despite its widely acknowledged limitations in e.g. acoustics, thermal stability (Dudek, 2000). Similarly, the way classrooms were put together in wings and pavilions on the basis of the principles of the corridor type remained largely unchanged.

NEW DESIGN PROBLEMS

This situation changed radically and rapidly with the educational reforms of 1995 (VSNU, 1998). The *second phase* and the *study house* stipulated by the reform were very different from the conventional instructivist system, mainly with regards to teaching methods. The changes resulted from new didactic and pedagogic views which were the result of general social and technological developments, like the electronic revolution. One of the fundamental assumptions of the educational renewal is that the learning process focuses on the student. Instead of amassing knowledge the emphasis now fell on obtaining skills and developing the learning process. The traditional school with mainly passive, listening students was transformed into a school with actively learning students.

Probably the most lasting influence of the reformations is that it opened the floodgates to didactic and pedagogical innovation. Where previously most schools seemed perfectly happy to follow the established path, it now appeared that practically every school was interested in some new, even novel ideas for modernizing at least a significant part of their education. At the moment of writing this, several Dutch secondary schools are known to pursue different didactic innovative models in the form of pilot projects, while the vast majority follows with interest.

On the architectural front this radical break with conventional forms is less pronounced. The most obvious changes have been the profusion of individual, generally computerized individual work places (usually spread around the circulation areas or crammed into a few spaces and especially the school library) and the addition of facilities for working in small groups (generally in some amorphous larger space). Many central halls (originally mainly used for circulation) have been transformed into a centrally located *study house*, with a variety of working places. These include individual computerized workplaces and group work places, which can be used by teachers with a small group of students or by several students working together on their assignments. The spatial structure of existing school types and of the classroom remained unchallenged, with the exception of a few small-scale experiments that used metaphors such as the living room as a classroom. UniC is a school where they have dispensed with traditional classrooms in favour of interconnected large and small workspaces. Each group of 75 students is accommodated in a wing of the building with their own living room and a number of different workspaces (Figure 8). The school is housed in an adapted office building.

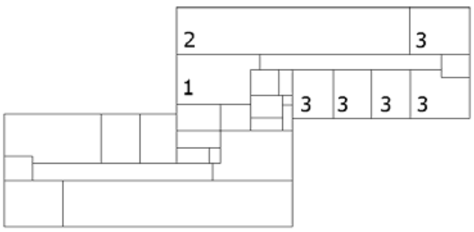

Figure 8. UniC: 1 = Living room, 2 = Large workplace, 3 = Small workplace

A school called "/21" chose for a configuration of several living rooms with individual work places connected to one another by a zone of work places for the teachers and a room for the students to relax (Figure 9). Four traditional classrooms were transformed into one living room, which now houses 50 students.

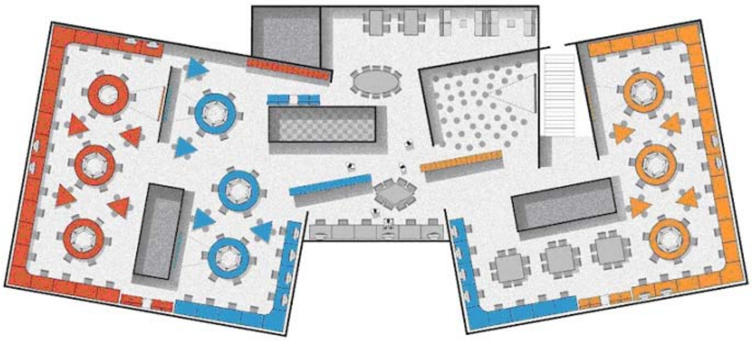

Figure 9. /21(Carmelcollege and Groep) (courtesy of KPC Group)

It is significant that when the first wave of radical innovation was over and the new didactic models started addressing practical problems, conventional school elements were reintroduced as solutions to new problems. For example, the classroom is seen as an appropriate solution to the need for cellular spaces for teaching in small to medium-sized groups. The negative experiences with the performance of the traditional classroom appears to already been forgotten (Dudek, 2000, Horne, 1999). The problem with large open, amorphous spaces is that there is a lack of spaces where one can work in silence. The instruction room at /21, for example, used to have an open connection to the living room but later it was possible to separate this space with moveable elements. They also added a new area separated from the rest to work individually without any disturbance. The Dutch changes as described above match the international developments (Wakefield and Kurz, 2004, Scheidegger, 2004), especially in the move towards more open-plan arrangements with a variety of different workplaces and the related multi-functionality of public areas.

BRIEFING FOR NEW SCHOOL BUILDINGS

The main problem with a brief for new school buildings is defining the conditions for the new activities. They can only be described analogically (e.g. similarities between a library or a free-plan office and a space containing a large number of individual work places) or negatively (negation of known conditions such as the conventional classroom). The solutions are equally unknown and untried and there are no real measures of building performance without extensive simulation, but even then there are too many unknown or vague factors. User participation and extensive analysis are required for the evaluation of existing environments and the development of specifications for new ones (Horne, 1999). Our approach is a three-step strategy (integration, correlation and analysis) which makes problems transparent and manageable without reducing the complexity or coherence of the overall design problem (Steijns and Koutamanis, 2004).

Integration

In conventional briefs programmatic requirements are usually distributed into a number of complementary documents that specify behaviour and performance from different viewpoints relating to different aspects or disciplines. The modularity of conventional briefs allows for omissions, vagueness and even conflicts between different aspects. A possible solution lies in facilitating the integration of different levels of abstraction and varying viewpoints (Horne, 1998).We use the brief as a collection point for all use requirements on the basis of the activities that have to take place in the building for all user groups. By summing up all stated and implicit requirements and their coherence one gets an integral brief which helps to treat local design problems. This list of all activities and their requirements can also serve as a basis for analysis and evaluation of performance in designing. The correlation of different issues and aspects into a coherent and comprehensive specification of each activity reduces programmatic conflicts and makes explicit underlying assumptions.

Cluster Languages									
Cluster	Code	Name	Type	Activities	# Users	Height	Public/private	Silence/noise	Accessibility
LA	Ls	English	CGI	teaching and learning English	032	4000	depends on the schedule	talking	ST
LA	Pd	department space		conferences, work (preparing lessons, marking papers, administration), tutoring	depends on number of teachers	2700	specific user	talking	T
LA	Lb	storage	-	storage of material of department e.g. books, tapes, tests and tv.	-	-	-	-	T
LA	S	lavatory	-	sanitary functions	-	-	permanentlyopen	-	STV
LA	Ak	education space for small groups	G	supervision of small groups, group work	010	3000	depends on the schedule	talking	ST
LA	Ai	individual workplaces	I	individual study	001	2700	Permanently open	silence	ST

Explanation of education type codes: C(lassical) G(roup) I(ndividual)
Explanation of accessibility codes: S(tudents) T(eachers) E(mployee other than teacher) and V(isitor)

Table 1. Integral description of spatial and functional requirements for the cluster Languages that are typically used in the early stages of an allocation process

The problems that arise while designing new school buildings for secondary education in The Netherlands, makes it a suitable field of application. The many and often complex activities that take place in a school building are variable in many respects, from the participants of the activities to the time and place where they occur. The new didactic approaches intensify this variability by creating more overlaps in functionality and localization. Consequently, the clustering of activities into larger groups should be flexible and adaptable. The resulting clusters should allow the analysis of programmatic problems at a higher abstraction level and support the recognition and treatment of wider issues (i.e. pertaining to larger parts or aspects of the design). This means that changes in clustering could be triggered by any party involved in the design process, including the clients and users of the school. In order to allow for changes in the primary clustering criteria (e.g. from user group to activity sort to building service type or intensity) as well as for cascades of secondary and tertiary criteria that refine and test the top-level clustering, we have implemented the brief in a relational database.

Correlation brief-design

It is important to enhance the interaction between briefing and designing by making information transparent along explicit communication lines (Voordt and Wegen, 2005), Therefore we couple the integral brief to the design in the computer. Thus we can automate analyses of all related aspects at any given time. Analysis becomes a permanent yet unobtrusive activity that supports creativity and communication. Direct correlation of brief and design also facilitates performance improvement in a couple of key areas, namely the management of project dynamics and design information visualization (Barrett and Stanley, 1999). By means of dynamic links between computer applications each activity in the brief database can become an annotation of a space in a representation (for example the geometric or topological representation). This linking forms the basis for the analysis of proposals for the accommodation of a new brief in an existing building. This applies to both the requirements on a single space or activity and the distribution of particular constraints in the building (e.g. climatic or acoustic conditions).

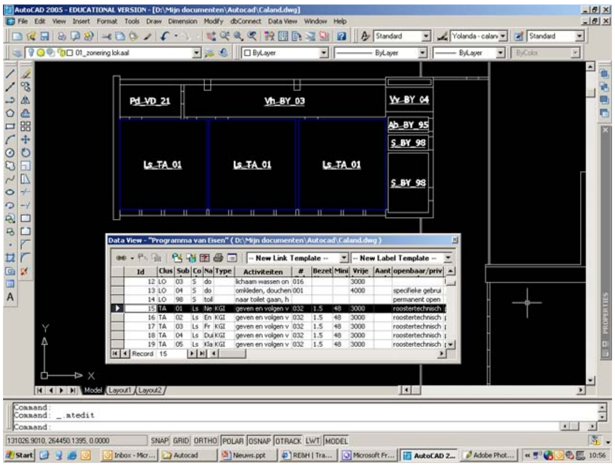

Figure 10. Dynamic link between a computer drawing of the existing building or design and the brief database with requirements

An example of an analysis that can be carried out automatically is a floor area analysis which compares the brief requirements with the actual floor area in a building or design. This makes it possible to continuously compare the measures in a design with the quantitative requirements.

Analysis and participation

The integration of programmatic requirements also makes explicit blind spots and gray areas in the client's thinking. These become subjects for active exploration which generally involves user participation (Whelton et al., 2004). The users of the school buildings often have a lot of experience with regards to the use of the building and the corresponding requirements. It is useful to involve teachers, students and the school board in the process. Participation is facilitated by the computerized brief and its dynamic links to the design in e.g. a CAD system. This allows users to develop alternatives and variations at a level of specificity that permits thorough analyses.

DISCUSSION

The main contribution of our approach lies in the transparent, coherent and consistent integration of use requirements into operational specifications for designing and building. The integral character of the brief helps overcome the shortcomings of a traditional brief, e.g. conflicts between different aspects of an activity or vagueness of the description. In conventional problems the significance of the integration of all requirements is not evident. In new, yet poorly understood problems, it contributes to the definition of goals and means and it supports communication between users, architects, managers and specialists, especially by of accurate analyses like the calculation of costs, lighting conditions, circulation or interior climate.

The main problems in the use of the integral brief are the amount and complexity of the information. These turn even small alterations of the structure or the verification of relationships between two or more activities into a complex, labour-intensive process. We think that the solution to these problems lies in the use of the computer. A database management system can facilitate the large amount of complex information and makes it possible to efficiently integrate the programmatic requirements in a reliable, flexible and powerful information structure.

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THE ARCHITECTURE OF THE CLASSROOM: CHANGES AND CHALLENGES.

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ABSTRACT

The architecture of the classroom is facing changes due to technology. In this information and technology age many questions have been asked regarding the future of schools and the impact of technology in education. Changes are needed in the classroom environment due to advances in technology and it will demand more investment, maintenance and management.

This research examines hi-tech (technology-based) classrooms environment through observation techniques and questionnaires. Results have shown that the use of new technology-based environments has positive effect on the learning process. Pupils seemed stimulated by the new technology and also by the appeal of the classroom space. Interactions proved to be increased. Developments in classroom design needs to consider technology as a key element. Flexibility is another important guideline in classroom design and workspace design.

Keywords: school architecture, learning environment, classroom, interactions

INTRODUCTION

This research focuses upon new hi-tech classrooms and it aims to investigate the impacts of these new environments on pupils, whether pupils' behaviour is affected by the change of environment.

Technology is changing rapidly and it is permeating all workspaces. In a changing world characterised by the information and technology age many questions have been asked regarding the changes in schools and their architecture. What are the schools of the future going to be like? What will be the impact of technology in early education? What changes are needed in the learning environment? What implications do they have in the architecture of schools and in the design process?

Evidences show the architecture of the classroom is already facing these technological changes. The classroom space becomes more complex and needs to be understood, well planned and designed in order to meet the demands of teachers, pupils and the community at large. Designing a classroom becomes a bigger challenge for designers. It has implications in the design process, especially in the briefing stage. The design team needs to be aware of the technological advances and to acquire knowledge on the field. Pupils are no longer end-users, but are seen as the client. Sorrell (2005) sustains that *pupils are the consumers of education*. It is necessary to understand this new context we live in, to understand the new technology and to understand the new learning environment it is creating. It is not a matter of inserting computer equipment in the classroom. The current challenge is to investigate how this new information technology can be used for the enhancement of teaching and learning. As stated by Bordwell, *"the challenge for educators, planners and architects to integrate instructional technologies is to recognize the magnitude of changes likely to occur over the next 25 years and to build schools that will meet these challenges."* (Crosbie, 2001).

A clear understanding about the classroom environment is fundamental to understand these changes. A good definition of learning environment is given by Wilson (1995) saying that *"a learning environment is a place where learners may work together and support each other as they use a variety of tools and information resources in their pursuit of learning goals and problem-solving activities."* This seems to be exactly what a classroom is facing now. A variety of new tools and information resources has been added to the environment since technology has been used to enhance access to information. In these terms a high-tech (technology-based) classroom used in this study is defined as an *intelligent classroom, which characteristically make extensive use of information technology and flexible environment* (Tiburcio & Finch, 2005*).* This latter definition suggests flexibility as another key element in classroom design.

Other questions might be raised regarding these changes in the classroom design. Are these changes really necessary? How do these changes affect the new architecture of schools and classrooms? What are the impacts on the pupils? Annesley (2002) argues that *"the design of a school affects the way pupils and staff interact, and their motivation and self-esteem"*. She continues by saying that *"these factors in turn have an effect on learning"*. Riggs *et al.* (2003*)* go further stating that *"students' academic achievement is higher in newer and more attractive school buildings than in less attractive facilities"*. The environment does influence education. Designing a school today requires incorporating new technology and creating spaces that are imaginative and stimulating to help children to achieve more. The main question of this study is concerned with the impact of high-tech classrooms on pupils' interactions. It is based on assumptions that relate learning to interaction.

Many Vygotsky "believers" argue children learn through interaction. According to (Doolittle, 1997) *"we learn through interaction with others and in doing so we create something qualitatively different from what we started with"*. Similar thoughts are presented by Littleton and Light (1999) when stating that "Vygotsky (1978) *saw these processes as highly susceptible of social influence and he focused mainly upon interactions between partners who differed markedly in their levels of ability"*. In another book (Light and Littleton, 1999) the same authors highlight that *"child's interactions with other people serve to mediate between the child and the world-to-be-learned-about and so understanding learning depends upon understanding the particular types of interactions which serve to foster it"*. To summarize it can be said that learning happens when interactions occur, which is an assumption for this research.

It is not intended, in this study, to measure the performance of the students in these new high-tech learning environments. From an architecture background and interest it is understood that learning is a very complex issue to be investigated and measured. The first interest of this research is to analyse the architectural space and its features. This study investigates if interactions are increasing in high-tech classroom environments and if there are connections with these technological changes. If interactions increase, it might indicate that learning will be improved, in other words, *more interaction more learning.*

CONCEPTUAL FRAMEWORK

Interaction is the behaviour aspect being investigated in this study. Three other factors that seem to influence it are also investigated: mobility of the teacher, flexibility of the room and the technology itself. With focus on pupils these interactions were classified in 5 categories (pupil-to-pupil, pupil-to-teacher, pupil-to-equipment, group interaction and no interaction) in order to be investigated and quantified. Observations indicated that relationships exist among these factors being investigated (Tiburcio & Finch, 2005). They are described below and grouped in a framework diagram (Figure1).

Technology and Mobility The new classroom has more equipment (laptops, web tablets, printers, interactive whiteboard, video-conference equipment, etc.) available for pupils to use and evidence suggested that it was being used. The teacher was significantly more mobile in the new environment.

Technology and Flexibility A relationship was observed between flexibility of the room and technology found with wireless technology together with movable furniture creating more flexibility in the observed new classrooms.

Technology and Interactions The technology available in the high-tech classroom allows more teacher-pupils and pupil-pupil interactions.

Flexibility and Mobility By comparing teacher's movement in the traditional and new classroom it was possible to identify greater support for mobility in the new classroom.

Flexibility and Interactions The flexibility allowed by the new classroom has encouraged meaningful interactions.

Mobility and Interactions It was found that the more mobility the teacher had, the more interaction occurred amongst pupils.

Figure 1 summarizes these relationships and shows that the technology in the classroom, the flexibility of the room and the mobility of the teacher have influence on the interactions that occur among pupils. It also shows that technology also influences the flexibility of the room and the teacher's mobility. In the same way, the flexibility of the room has a relationship with the mobility of the teacher. The diagram represents the conceptual framework for this research and it was the base for data gathering. These relationships suggest that more interaction is stimulated by the new technology-based classroom.

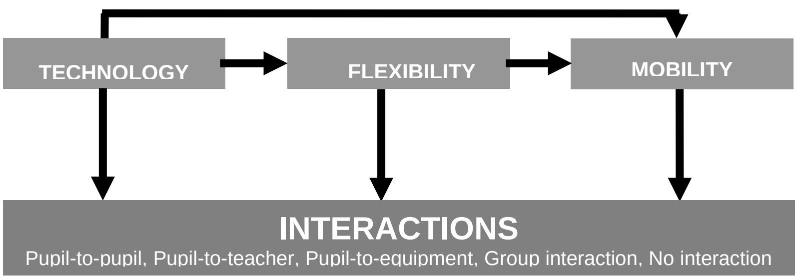

Figure 1 Conceptual Framework, adapted from Tiburcio and Finch (2005)

METHODOLOGY

Methods from environmental psychology underpin this research since they offer tools to analyse the space. This research is based on case studies constituted of two new classrooms and two traditional classrooms in different schools. Behavioural mapping (through class observation) and questionnaires (to validate some data) were the methods used in this study. This multi-method approach is suggested by Zeisel (1984) since each method has it own bias.

Behavioural mapping, which uses a plan to annotate observations (Tiburcio & Finch, 2005), was chosen and several graphic maps were produced during each observation session. Every 5 minutes a map of the physical space was produced and information was registered. This technique has been used for environmental psychologists such as Ittleson *et al* (1974), Zeisel (1984) and Horne (2002). The latter used behavioural mapping to examine the classroom focusing on the teacher. This study has the focus on pupils. Figure 2 shows a plan of the classroom extracted from one of the observation sheets with information recorded. The observations were mapped on floor plans of the classroom, annotating layout, teacher's movement, interactions among users (pupils and teacher) and with the environment, record of activities and their duration.

The use of questionnaire at the end of the observation process allowed the validation of the data (Horne, 2002) collected from observations. The focus of the questionnaires was the view of the users on their experiences in the new environment. All pupils in the classes were given a questionnaire. It was agreed with teachers that questionnaire would be a class activity, which produced a large number of responses.

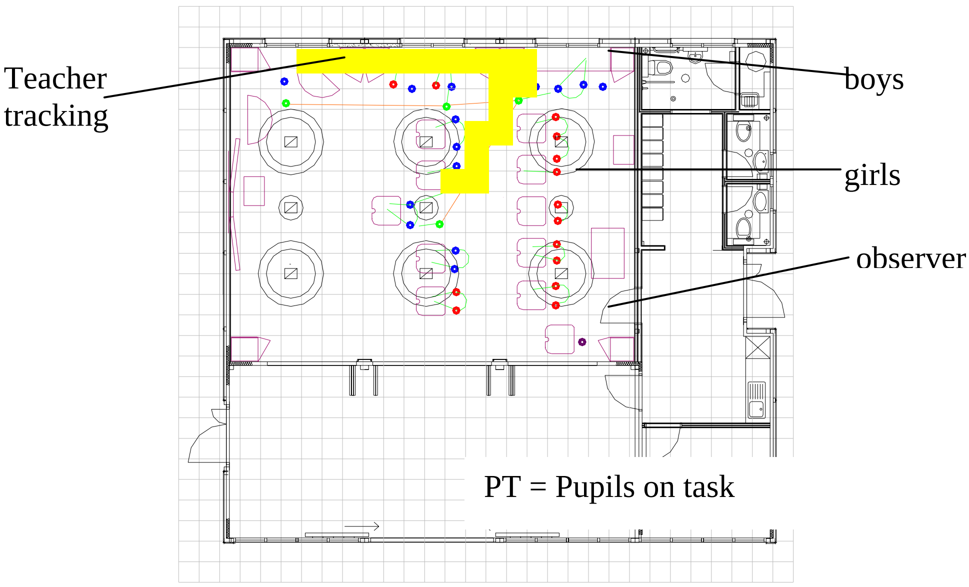

Figure 2 Five-minute behavioural mapping

EXPERIMENT

The research used case studies for data collecting. Two schools in Telford-UK, designed by INTEGER - Intelligent and Green (INTEGER, 2004) were chosen due to their new built high-tech classrooms. One primary school (Wrockwardine School) and one secondary school (Lord Silkin) were granted with a new "classroom of the future", part of a Government initiative (DfES, 2003). Four classrooms were used for observation and comparison, two traditional classrooms (WTC and LSTC) and two classrooms of the future (WCF and LSCF). The same group of pupils (class), the same teacher and the same subject being taught in both traditional and new environment, were chosen in each school. It allowed, through comparison, to investigate whether interactions have increased in the new environment. Figure 3 represents the framework for the experiment explaining how the comparison was made. It guided data gathering and analysis.

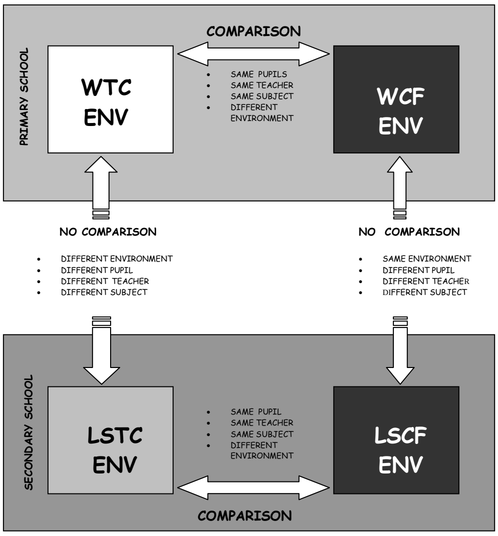

Figure 3 Framework for empirical studies

The traditional classroom environment in the primary school (WTC) is just like in many other schools. To attend 7-9 years old pupils the tables are arranged together for group activities, walls are used as information and work displays, and it also has got a blackboard, an interactive white board and some computers. The last ones were rarely used during the observation period. In the secondary school (LSTC), the traditional classroom has a horse-shoe shape layout that encourages the teacher to be on the front of the room and students sitting around the tables. Both classroom of the future (WCF and LSCF) have the same design, apart from the furniture in the conservatory space and the outside cladding. The classroom itself has top technology such as laptops, web-tablets, video-conferencing system, printers, interactive board, audio-video equipments and movable wheeled desks and chairs. It has got automation features for the building, green roof, light pipes, light sensors, since it was conceived as intelligent and green building (Dawson, 2004).

FINDINGS AND DISCUSSION

The flexibility of the classroom is higher in the new classroom. In both schools (W and LS) the classroom of the future have higher flexibility factor (Figure 4). In average the difference between old and new is 12% and it is considerably significant. The attitude of the teacher is changed in the new classroom. The layout, for instance, was always changed, while in the traditional classroom it was kept the same most of the time. This flexibility seems to have fostered the teacher to be more mobile in the classroom. Figure 5 confirms that teachers have more mobility in the new classroom. In both schools the mobility factor of the teacher has doubled. By being more mobile teachers tended to interact more with pupils.

The number of interactions has increased in most of the five categories identified as pupils' interactions. This can be illustrated by Figures 6 and 7, for the primary and secondary school classrooms respectively. In pupil-equipment category it was expected that this number would be much higher since there are more equipment available in the classroom of the future. Pupil-teacher interactions show significant increase in the new classroom, confirming that higher mobility of the teacher would increase interactions with pupils. The pupil-pupil category also shows increase in the number of interactions in both new classrooms. Group interaction presents a lower value in the new classroom. When looking at the "no interaction" category it is clear that the overall number of interactions has really increased since there are much less *no interaction* in the new classroom.

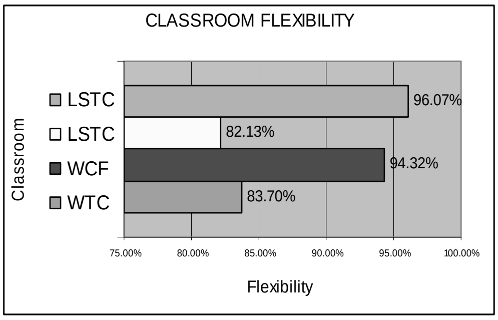

Figure 4 Comparison of flexibility of the classroom

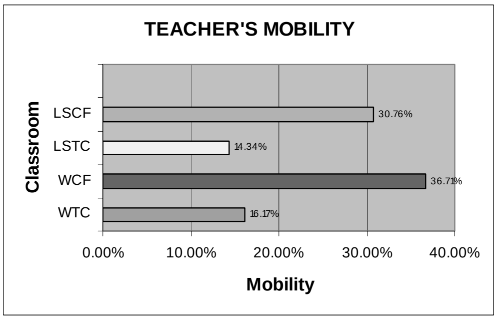

Figure 5 Comparison of the mobility of the teachers

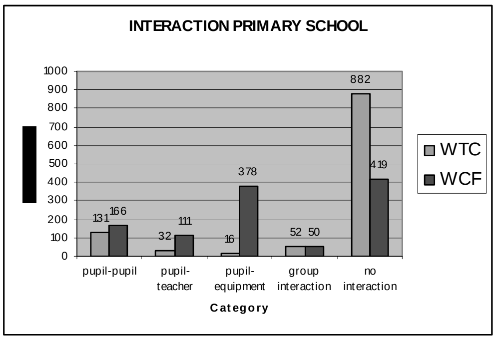

Figure 6 Interactions in the primary classrooms

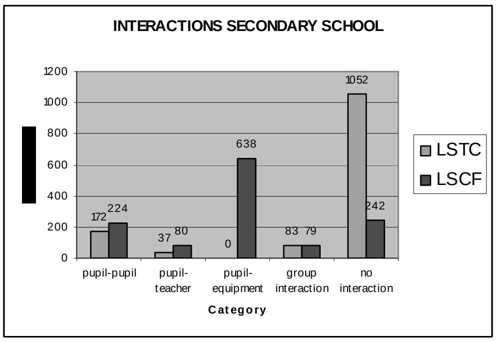

Figure 7 Interactions in the secondary classrooms

According to the questionnaires these findings discussed above were also perceived as positive by students and teachers. A total of 51 questionnaires were given out to students of both schools and a 98% response rate was achieved. This was guaranteed by using part of the lesson for the students to answer the questionnaires. 13 teachers were also asked to answer the questionnaire (85% responses). When asked about the technology in the classroom and the interactions that occur in it most of the answers were in the upper grades of the scale (agree and strongly agree).

Question 20 asked *if the pieces of equipment are helping them to learn more* and 28% of pupils agreed and 36% answered strongly agree. This means a total of 64% signalling positively for the use of technology in the classroom. Teachers confirmed these findings with a total of 82% who agree with that and 9% strongly agree. This indicates that learning might improve with the help of technology.

Regarding interactions, question 29 - *the classroom of the future allows you to interact more with your peers* – had 32% saying strongly agree and 24% agree, summing 56% positive against 16% who disagree or strongly disagree. The other 28% are neutral in the scale (neither agree nor disagree). Teacher had 73% positively agreeing that the new classroom fosters more interaction. 51% of respondents agree or strongly agree with the affirmation on question 38 – *I learn more when I interact more*. 5% were contrary and 44% neutral. By looking on teachers responses, 91% agree with this statement and 9% strongly agree. None of them were contrary to this idea.

Others responses also indicate that interactions have increased in the new classroom of the future. However they are not discussed in this paper. The relationships that occur in a high-tech learning environment presented in the diagram on Figure 1 are supported by positive answers.

CONCLUSION

Changes become clear in the classroom environment. Technology and flexibility are two main elements that designers must deal with when designing a classroom. The flexibility existent in these new classrooms facilitates interactions to occur and it seems to help group and independent learning. Regarding technology it is important to understand the spaces for learning and what are the impacts on pupils and consequently in education. It is not only a matter of building ICT suites in schools. The present challenge is to know how technology will help to improve learning acquisition.

The new approach points to bring technological tools into the classroom. In other words, instead of taking pupils to have lessons in a computer lab to learn about computers, teachers would have these tools in their classroom to facilitate access to information. The teacher becomes a facilitator in the learning process. More interactions will occur, as found in this research and consequently higher achievements might be reached.

These changes and challenges have new implications for those involved in the design of a classroom such as architects, designers and engineers. From the architecture point of view it suggests a new way of thinking, understanding and designing a classroom environment. In the field of architectural management, the briefing process, for instance, will require involvement of pupils playing a role of the main client. The classroom is designed for them. They are the target for learning and the space has to meet the new demands. Involving pupils in this stage will help to design innovative learning environments that can adapt to educational and technological changes.

The impact of technology in school buildings, as studied in this research, can be transferred to other typologies of building. Impacts on the architectural management field seem to initiate in the briefing process as suggested for school buildings. In this information age, technology is reshaping most of institutions and fostering buildings to change. Consequently, the whole process of building changes and the management will be affected.

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Acknowledgement: ***Research sponsored by CAPES, Brasilia, Brazil.***

DESIGN INTEGRATION

INTEGRATED PRODUCT DEVELOPMENT IN BUILDING CONSTRUCTION: CASE STUDIES IN BRAZILIAN BUILDING COMPANIES

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Abstract
This paper presents a literature review about concurrent engineering and proposes a new model to analyse building design process. Concurrent engineering in the real estate and building construction sector is treated as an early bi-directional integration of three development process interfaces in the building project. A theoretical, concurrent engineering oriented model has been developed and put against descriptive case studies in three of the greatest Brazilian companies of real estate and building construction. As conclusions, a diagnosis of the integrated product development in those studied companies and some guidelines to improve the integration and the management effectiveness in the building design process are presented.

Keywords: Concurrent engineering, design management, multidisciplinary teams.

INTRODUCTION

In the face of the increasing demands in relation to products and processes, companies have been searching for new methods to develop their products and services, looking for quicker responses to the market changes and the new demands from society. Several companies from industrial sectors that employ state-of-the-art technology have been developing their products in a more integrated and collaborative way, by means of design methodologies characterized by the integration of the players involved in marketing, design and production of new products, according to the concurrent engineering approach.

The more classic definition to Concurrent Engineering (CE) is "...a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developer, from the outset, to consider all elements of the product lifecycle from concept through disposal, including quality control, cost, scheduling and user requirements." (Institute for Defense Analyses – IDA, 1988) apud (SPCD, 2002). And, the fundaments of CE, according to several authors, as Hartley (1992), Love and Gunasekaran (1997) among others, are:

- Multidisciplinary team participants interaction, emphasizing design coordination role;
- Product and production designs integrated development;
- Design integration of production process different players approaches. This is expected to occur by multidisciplinary team implementation that considers, while elaborating the design, the product life cycle;
- Strong customer and user satisfaction orientation (transformation of customers desires into design specification), eliminating activities that do not add value to the product.

Table 1 presents a brief summary of the concept and evolution of the concurrent engineering definition as proposed by many authors.

Table 1 - Characteristics and concepts of concurrent engineering

AUTHOR	ELEMENTS CONSIDERED IN THE CONCEPT OF CONCURRENT ENGINEERING			
McHugh; Wilson (1989) apud Junqueira (1994)	Focus on the needs of internal and external clients; Designing according to DFM process and organization aiming at parallel activities.			
Chamberlain (1991) apud Junqueira (1994)	Defining project goals; Teamwork; Parallel developing of activities; Design standardization and design management process.			
Carter; Baker (1992)	Organization; Team integration; Training and Education; Support Automation	Communication Infrastructure; Product management; Product data availability; Feedback	Requirements and needs definition; Methodology planning; Prospective planning; Validation; Standardization	Product development; Value engineering; Optimisation
Schrage (1993) apud Huovila et al. (1994)	High-level approach to the project, based on engineering systems; Strong client interface; Multifunctional and multidisciplinary teams; Project benchmarking and digital model prototyping; Simulation of product performance and support and manufacture processes; Simulation and evaluation of major predictable risks; Early involvement of subcontractors and salesmen; Company focusing on the continuous learning and improvement.			
Murmann (1994) apud Huovila et al. (1994)	Clear definition of the project objective; Resources concentration in the beginning of the project; Predevelopment aiming at reducing technical uncertainties; Improving project planning; Superposition of the development of parallel tasks; Increase of the project administrator's competence and responsibility; Developing specialized and multifunctional knowledge; Early consideration of the feasibility of the design concept; Promoting the communication among employees; Intensification of time control and development cost.			
Hartley (1992)	Multidisciplinary design teams; Product definitions focusing on the consumers; Product and manufacturing process simultaneous development; Marketing and quality control.			

According to Love and Gunasekaran (1997) CE application into construction products development may mean an important strategy to solve several deficiencies during project life cycle. Table 2 presents several construction problems that may be CE approached.

Table 2 - Improving construction efficiency by concurrent engineering strategy (Love and Gunasekaran 1997).

	Construction Issues	**Concurrent Engineering Strategy**
Quality	Clients' and end user Requirements	Systematic consideration of clients and end user requirements
Information flow	Interaction between participants	Team-building, proactive management, collaborative decision making
Efficiency	In-depth constructability analysis	Focus on the design and development phase
Project completion time and cost	Subcontractors, major subcontractors, rework and errors, inflexible procurement systems	Quality design and documentation, involvement of subcontractors and major contractors during the early stage of the design phase, CIM, robots.
Major cultural, behavioral, organizational, behavioral issues	Clients' and end user participants for co-operative supported work	Leadership, motivation, incentives, training, multimedia
Design optimization	Non-value adding actives, delay in the project completion	Design for constructability, design for quality
Elimination of non-value adding activities	Physical movement of resources, information exchange and hand over between subcontractors	JIT, life cycle design for construction, activity-based analysis

Despite its potential, construction CE application should be approached considering the sector characteristics that present several differences (partially listed on Table 3) from the industry as whole. Therefore, in order to implement construction CE practices it is necessary to define models and methods that may answer specific sector problems (Tahon 1997). Deep transformations, that include (i) firms and project organization, (ii) participants culture, (iii) new technology that support information and project must be introduced.

Table 3 - Construction peculiarities that may interfere on CE application (FABRICIO; MELHADO; BAÍA, 1999)

Construction project Nature	Project planning and programming, conception and design and production are much more spread in construction.
Culture and related Aspects	Players inter-relationship are much more temporary and contractual, not repetitive project cycle oriented; Differently from manufacture, as a whole, the clients generally interfere significantly on project internal management.
Suppliers	For several market and geographic reasons, same supplies maintenance, to different projects, is very difficulty; Considering firms involved different sizes, the negotiation power, concerning to suppliers is more limited.
Production scale	Construction usually works with small scales. This relatively decreases the product cost amortization possibility.
Construction site limitations	The production place (site) is more vulnerable to variations and climate phenomena in construction.

AIMS AND METHODS

The object of the present article is to translate and adapt the concurrent engineering concepts to the Brazilian building construction industry reality, together with the building real estate and construction sector, by means of operational guidelines that are adequate for this sector's reality. This paper focuses on the integration and collaboration of several existing interfaces among the players involved and through the development phases of building projects. This article has evolved from a literature review on concurrent engineering and from descriptive case studies of two large Brazilian real estate and building construction companies. A model is presented to analyse the product development interfaces in real estate and building construction companies in the face of the references provided by concurrent engineering methodology (item 3), critically analysing the product development process in the two studied companies (items 4 and 5) and directions and the necessity to implement concurrent engineering in building construction and real estate companies (item 6) are pointed out, from an analytical extrapolation of the case studies results.

PRODUCT DEVELOPMENT INTERFACES IN BUILDING CONSTRUCTION

Throughout the development of a new building project several formulations, designs and plans are developed involving different players, making it possible to identify a series of interfaces between these stages and players. Due to the number of players involved in the design process, an organization of the information flow and competent management of the design interfaces deem necessary (Oliveira, 1999). In the sequential process of the product development the interfaces occur mainly in an unidirectional way, that is, after the formulation or conception of an aspect of the project design the generated information is passed on and such information is the starting point for the next stage.

The first interface (i1) lies between the market (demand) and the developer, and it can be named as client interface. This interface concerns the intermediation between the clients' needs and economic conditions and the development of a design. The interface between the speciality designers (i2) is a classical one and is related to the coordination of the designers' performance and the development of different design disciplines.

The i3 interface is related to the feasibility of the designs and to the development of the design for production, which can solve the constructive methods of the subsystems in the site work according to the product specifications. Interface i4 represents the need to follow up the construction and prepare the "as built" so as to guarantee the feedback of future designs and the maintenance of the constructed building.

Interface i5 is related to the project follow up during its use and maintenance phase so as to measure the accomplished results and the clients' satisfaction, by means of performance and post-occupation evaluations which investigate the performance from a technical point of view as well as from the perspective of the end users. The results of the evaluations should foster the development process of new projects thus creating a learning dynamics and the perfection of future projects.

Jouini (1999) and Melhado (1999) have identified three main interfaces in which *cooperation* and *integration* practices can be established. These interfaces are represented in figure 1 as (i1, i2 and i3) together with feedback on the execution (i4 – building interface) and usage (i5 –performance of the product being used by the client interface) phases. Figure 1 also makes a reference to ISO 9001:2000 with the process beginning with a client from the point of view of their needs and ending at the end user client with the performance of the product or service.

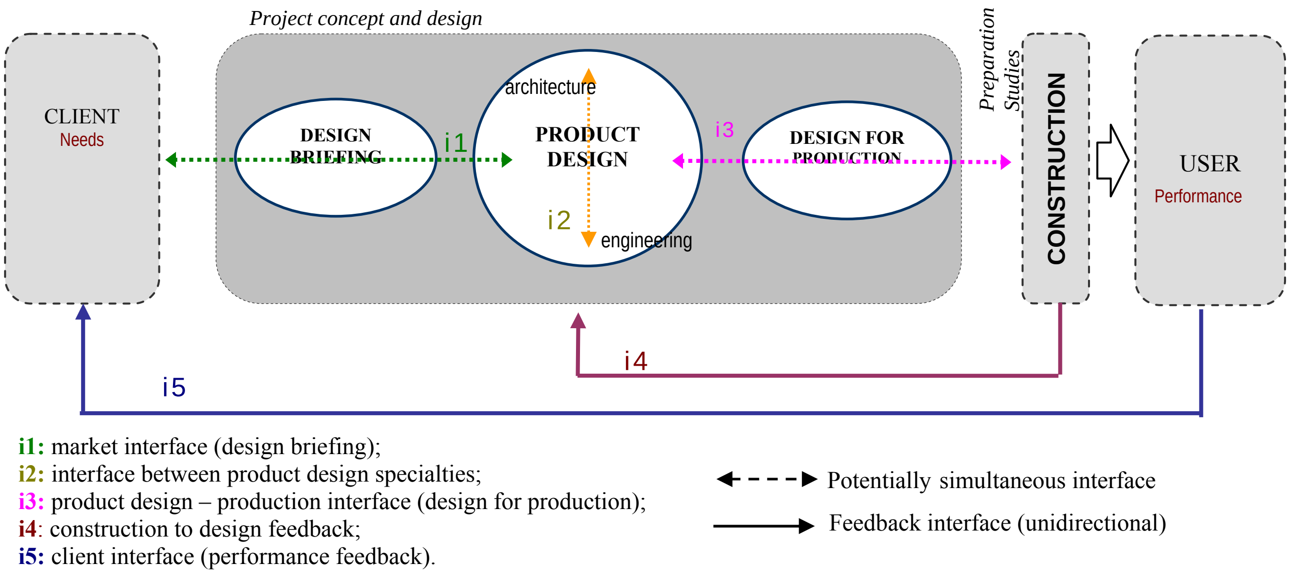

Figure 1. Main interfaces in the design process (Fabricio, 2002)

Based on this product development interface model two case studies in real estate and building construction companies. This kind of company carries out private projects, involving both the project development (financial scheme set up and real estate business) and the building and construction management.

CHARACTERIZATION OF STUDIED COMPANIES AND THEIR PRODUCT DEVELOPMENT STRATEGIES

Case "A"

Case **"A"** is a private real estate and building construction company of national capital that was founded in the state of Minas Gerais in 1969. Nowadays it is considered to be a large company with circa 2500 employees, acting in the Minas Gerais state and the Distrito Federal, and in the State of Sao Paulo for eight years.

This company is aimed at high-income housing developments (high and medium standard apartments) as well as in the construction of commercial buildings (offices, stores, flats and shopping centres). The company has constructed over 200 buildings, 66% of which are high standard residential buildings, 14% medium-standard residential buildings and 20% commercial buildings. The company also has a QMS certified against ISO 9001 standard.

In company **“A”**, the selection of the sites to be acquired or exchanged is guided by its location and the opportunity to incorporate good areas, in privileged neighbourhoods in each city. The process of designing new buildings starts with the feasibility and concept analysis of a new project, leading to the product design phase, in which the design for production is also developed. The development of the business and the new projects briefing follows the classical strategy from the possibility of initiating a new project and a finance and economic feasibility analysis that will support the new project. As the company acts in market sectors with high standard of living (high income class), the definition of the project briefing is made in a more personalized way, according to the demands of this specific market.

In order to define the briefing of each building the following professionals are summoned: a real estate team (marketing and project analysis, financial analysis and land analysis), the company’s technical team (technical superintendent, design coordinator, site management team), and the architect. The engineering designers are contracted at a later phase of the design development. The company also creates design for production patterns of a series of subsystems of the building (e.g. windows and doors, façade covering, masonry, formwork design, etc), according to the list presented in Table 4. Such designs are subcontracted and developed concomitantly with the product design, to the exception of the formwork design, which is made *a posteriori*.

Table 4 – Design for production specialities – case study: Company A (Fabricio, 2002)

	DESIGN GROUPS	DESIGN SPECIALITIES / SUBJECTS
Design for Production	-	Concrete structure formwork; Partitions; facades; windows, doors and frames; Rationalized slabs; reinforcement; ceramic tiles; mortar; Waterproofing; etc.
Consultancy	-	Cost; Budget; Buildability improvement; Critical analysis of structural design; Critical analysis of HVAC design; etc.

Contracting the designers takes into account previous experiences, assessing the designers’ qualifications according to the QMS of the company, and, as a last criterion, reference from other clients.

An architect from the building company is responsible for coordinating the design, and such professional is in charge of conducting all the design process as well as validate the solutions proposed by the subcontracted designers. The design validation and the compatibility among specialties is extremely valued in the company and the design coordinator is responsible for checking the designs with the help of an extensive checklist. The coordinator must also superpose the several designs and verify the compatibility among them. This analysis is carried out by a matrix analysis system, which forces the coordinator to give an opinion about the compatibility of the designs in each quadrant of the matrix.

Case “B”

Company **“B”** is a major real estate and building construction company specialized in housing, acting in the middle class sector in several cities in the country, but its main market is in the city of Sao Paulo. Nowadays this company has a quality management system for its process of real estate development and construction of residential buildings – certified against ISO 9001 standard.

The competitive strategy of this company focuses on the search for cost reduction and the improvement of sales conditions of their buildings so as to make it possible for middle class consumers to buy apartments straight from them (Fabricio, et al. 1999). In order to make this strategy viable, the company has designed a self-financing scheme of their projects in which a considerable part of their construction cost is financed by the clients themselves and by prolonging the time for payment.

Prolonging the time for payment influences a series of briefing and design decisions. Thus, the choice of fast construction alternatives is not of great importance, once the duration of the project is not determined by technical limitations, but by the financial capacity of the clients. This favours the technological alternatives that present lower execution costs, regardless the required construction time.

In this context, the adoption of industrialized and prefabricated constructive techniques is not stimulated, favouring the rationalized traditional construction processes, which are more adequate to the "project duration *versus* payment flow" balance. In fact, this seems to be the strategy adopted by the company to allow a better result of their projects cash flow. While the structure and vertical sealing are designed with traditional technologies (*in site* formwork concrete or structural masonry) the installation and finishing projects are designed to be executed fast, near to the project delivery date. This way, many of the adopted design solutions such as ready shafts, windows and doors, exemplify the existence of designs focused on a greater rationalization of the solutions from a technical point of view, associated with the viability of the adequate cash flow. By allowing a slow execution of the project at the same time delaying expenses with important sub-steps of the construction process (installations, finishing, etc), the company meets the clients' wish to see the project advance, besides assuring a better cash flow for the project (Assumpção, 1996).

To complement this cost reduction strategy from the production point of view, the company has been making an effort to standardize and simplify their buildings, reducing the costs by eliminating expensive design details and by large scale gains with the large series of projects, which allow the maintenance of a relatively constant number of construction sites, thus reducing the final cost of the projects and guaranteeing a relatively constant volume of demand input.

Following the standardization strategy, the design briefing of each project derives from a pre-established basic briefing, developed by regional product and marketing directors. In order to prepare the basic briefing, the market experience of each regional branch of the company is taken into account and qualitative surveys are carried out with the potential consumers. With this information, meta-briefings are developed for each region where the company acts in, so as to ponder on the regional idiosyncrasies (larger balconies in Rio de Janeiro and seaside cities in general, balconies with a barbecue grill in Porto Alegre, badminton courts in Minas Gerais, etc).

From the typological definitions (basic briefings) of products that meet the needs of a selected market niche, the company develops a series of standards and procedures for concept and design, which serve as guidelines for the design development. The selection of the site, one of the first decisions in the concept of the project, is subordinate to the search of sites that adequate to the kind of product and the clients niche the company wishes to reach. From that, the design briefing follows the pre-established patterns of the company.

The simplification and standardization achieved by the company make it easier the development of partnership with suppliers, once they allow the company to work with a reduced number of well-known brands and types of materials, components and services, taking advantage of their large scale production to negotiate better prices of these items. The preoccupation in designing the production is, according to the company, incorporated to the product executive design and the production standards and procedures in its QMS and, specifically in masonry, to contract a design for production specialist.

With regard to the relationship of the company with the other project players, it is possible to identify two main types of partnership with distinct reach, involving materials, components and design service suppliers and subcontractors. Not only is this distinction between partnerships due to the nature of the given input – product or services – but also to the power of negotiation with suppliers and to the objectives of the company for each kind of input.

As to materials and components, the company concentrates on the establishment of partnerships with well-known suppliers on the market in order to obtain better buying conditions and, in some cases, as a marketing strategy, guaranteeing to their clients that their apartments will be built with materials from respected brands.

The strategy for service suppliers and subcontractors is far more comprehensive and ambitious. In the case of partnerships with designers, the company has developed a series of patterns and standards of design presentation aimed at certain standardized criteria and solutions, so as to simplify the plans and guarantee a better construction besides making design more transparent, manageable and adequate to the site work environment.

When contracting designers, partnerships with professionals already familiar with the company's practices and design standards are taken into considerations, besides following the qualification criteria and suppliers evaluation of the QMS of the company. The company also demands that meetings are arranged with the designers so as to coordinate the design along its development. The meetings schedule as well as the partial and final design presentation deadlines and the information exchange moments among the designers are defined at a first meeting.

The company adopts a similar policy with the subcontractors. They are expected to follow a series of construction procedures and meet the deadlines established by the company. In order to guarantee the fulfilment of the procedures and deadlines, the company and the subcontractors carry out brief training sessions with the workforce at the beginning of each task considered important.

Therefore, we may highlight, according to Fabricio et al. (1999), those partnerships do not necessarily guarantee an equalitarian relationship among the involved parts. In the studied case, the construction company exercises its preponderant negotiation power with the designers and subcontractors, thus moulding partnerships according to their strategies and at their convenience.

THE PRODUCT DEVELOPMENT INTERFACES FOUND IN THE CASE STUDIES

In relation to **interface 1** (design briefing-detailed design) companies **A** and **B** start from the traditional references from the market, prizing the definitions consolidated on the development and sale of previous projects and, occasionally, from carrying out qualitative market surveys.

In company B, the briefing integration with other decision areas is strongly guided by a meta-briefing, established by internal standards and procedures that serve as reference to the designers. The design briefing in company **A** is made from case to case, which allows a more collaborative "i1" in relation to company **B**. However, an important limitation is the absence or the informal participation of the designers responsible for the product engineering and the design for production. As to **interface 2**, in all analysed cases initiatives with the intention of qualifying the coordination process of the design for production were noticed.

Company B has developed its own coordination process, establishing in a more precise way the designers' responsibilities and defining a series of products criteria to be followed (design standards and patterns), as well as a rigid code system and design presentation and the use of icons instead of the standard symbols to describe information such as light, telephone, etc more clearly, making the information in the design more transparent to the workforce in the construction site.

In both companies design coordination meetings used to be more numerous. However, with time it was noticed that one, two or three meetings at most, are enough to establish contact among designers and between these and the construction company, which shows greater maturity and objectivity in the organization of such meetings.

The use of electronic media (e-mail, Internet, Intranet, Extranet, etc.) has increased in both companies, as a communication tool and to exchange projects, reflecting a growing tendency of using nets to manage information in construction. In both companies the exchange of design files is organized in a way it is centralized in the construction company, i.e., the exchange among the designers are mediated by the design coordination department, which is responsible for the information control. In company **B**, the coherence between detailed design and briefing (i1) as well as the coordination of the product design (i2) are based *a priori* on the design standards and patterns and on the pre-established basic briefing. Therefore, the case-to-case collaboration in the design concept is replaced by the company's strategy premises, which underlie all the planning and briefing process of the project. Despite that, the company has been successful in developing products that meet their business strategies and satisfy their clients.

In both companies the engineering and specialties designers are hired after the architectural scheme design is developed, that is, when various concept decisions had already been made. This attitude brings a double problem to the collaboration among the designers: on the one hand, the existence of ready and consolidated architectural solutions makes it difficult and does not stimulate that suggestions are made on the part of other designers, who tend to conform to the given conditions; on the other hand, when important suggestions are made and accepted, the architectural design has to be remade. The product engineering specialties designs are developed simultaneously. However, even among these many design coordination and integration problems can be observed, such as the difficulty to find a compatibilization tool and the time spent on information exchange among others.

In the studied cases, only company **A** makes extensive and systematic use of designs for production. Company **B** justifies the absence of such practice with the incorporation of building execution specifications to the product design.

In fact, the simultaneous **interface 3** only is extensively developed in company **A**. In this case, the design for production is initiated before the product design is ready. Besides the subcontracted designers, the company invites the future site engineer of the building that is being designed to take part in “i3”. This allows both the anticipation of how the building is going to be produced and the discussion about the feasibility of the product design.

In company **B** the development of a new design code system with colours and icons, aiming at a greater transparency of the design plans with the workforce, represents an interesting integration effort, even if limited, between the design and the site work (interface i3).

In company **A** concrete actions and preoccupations to aggregate their building experiences and their clients demands and complains to the concept and development of their briefing and detailed designs were observed, creating a **fourth interface – i4**.

This company has also introduced an automatic process of recording complaints and suggestions made by their buildings end-users, monthly systematized into Pareto diagrams, which support the concept of new projects. For example, based on the complaints on the noise made by the installations, the company has determined that the shafts cannot be designed next to the bed headboard, demonstrating the existence of feedback related to the **fifth interface – i5**.

CONCLUSION

Concurrent engineering applied to building construction must seek to guarantee a collective authorship in the building design process by coordinating the efforts of different design players and specialists from the beginning of the product concept and development process, aiming at integrated and global solutions.

The case studies have indicated a greater preoccupation on the part of the companies with the design process, especially with the design coordination (i2) and with the integration between design and construction phases by the growing introduction of design for production. (i3). In this sense, it is possible to identify that the building companies are seeking more integrated design practices. However, the absence of a strategic plan for introducing new management models causes what can be described as a partial and problem implementation of concurrent engineering, with the concomitant adoption of innovative procedures and traditional practices, what many times creates conflicts and limits the potential of improvement of the new practices.

Another lesson that can be learned from the studied cases is that there are many different practices to organize, manage and integrate the building design process, which demonstrates that it is possible to introduce new and more integrated management practices, and that the design process and the production process in the sector is not predestined to reproduce classical models and stages.

In the studied cases it was possible to identify positive points in the design coordination, especially related with the coordination efforts between specialty designs and between these and the building team. Still, there is not yet a treatment of all the interfaces combined. The efforts of modernization in the design management process in the studied cases, however promising the partial results may be, demonstrate the absence of models capable of globally treating the integration of the design process with the client function, with the construction processes and finally with the whole project life cycle. In order to attain the integrated development of the potentially simultaneous interfaces, according to the model presented, the three major development interfaces of a building must be treated as a whole.

On the one hand, it is necessary to make a deeper development of marketing techniques and the relationship of the promoting companies with the clients and users in the first interface (i1). On the other hand, it is fundamental to have a more dialectical relation between the design briefing and the design detailing decisions.

As interface (i2) is concerned, it is clear that the design coordination must be recognized as a fundamental activity in order to guarantee the coherence among the specialties solutions, and to do so, a coordinator must take upon the task of promoting information exchange and mediate the conflicts among the various designers.

For the interface between the design phase and the building (i3) it was discussed the use of design for production and integrate a deep reflection about the construction process in the design stage, so that the design decisions take into account the developments regarding the building and its construction.

The empirical evidences and the literature analysis have made it possible to confirm the hypothesis that the building design process can be qualified and optimised by introducing new management practices based on the premises of concurrent engineering. However, they must be adapted to the building construction conditions and to the particular needs and possibilities of the building projects.

The adoption of the concurrent engineering represents a significant advance in the way of focusing the product development in building construction, involving in the design process all the aspects of a project life cycle and it can allow to improve the performance of the design process, thus improving the building product quality.

With the perspective of formulating an analysis on the possibility of transformation of the design process management as guided by concurrent engineering, multiple implications and potentialities related with the theme have been investigated. This way, countless questions were raised, but definitive or thorough answers were not given. In fact, these topics are part of a mosaic of subjects approached in a PhD research (Fabricio, 2002), which indicates that additional studies can be made in order to clarify the raised problems and tendencies.

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INTEGRAL DESIGN METHODOLOGY IN THE CONTEXT OF SUSTAINABLE COMFORT SYSTEMS

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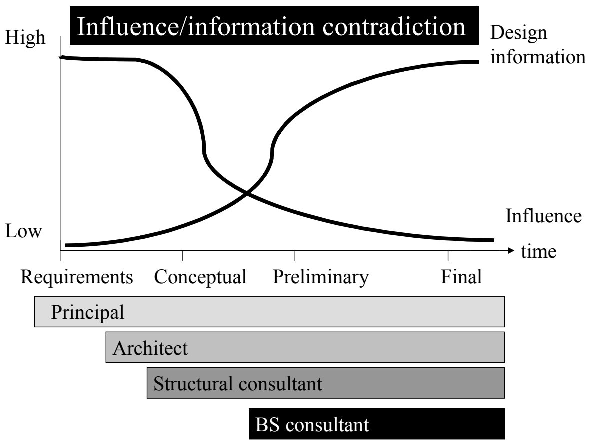
Abstract
The application of sustainable energy in buildings becomes more likely by offering design teams new conceptual support framework inside the specific domain of sustainable comfort systems, thus making their integration in early stages of building design easier. In 2000, the Royal Institute of Dutch Architects (BNA), the Dutch Society for Building Services (TVVL), and Delft University of Technology (TUD) started a research project on Integral Design, resulting in a series of workshops for architects and HVAC consultants. This project is succeeded by new research within the Knowledge Centre Building & Systems (KCBS), in which Eindhoven University of Technology (TU/e) and TNO Environment and Geosciences work together. The ongoing workshop series, in which already more than 200 professionals from BNA and Dutch Association of Consulting Engineers (ONRI) participated, are used for development and evaluation of an integral design methodology. Using methodology for structuring and documentation of design processes enables verification and reproduction of the decisions made during designing. Besides its added value for building design, this integral design methodology directly stimulates application of sustainable energy in the built environment. It introduces iteration cycles on a level of domain itself that in time reduces the number of iterations needed during new design tasks because of the emergence of a design language that helps structuring the design knowledge and methods.

Keywords: Design, integration, methodology, sustainability

INTRODUCTION

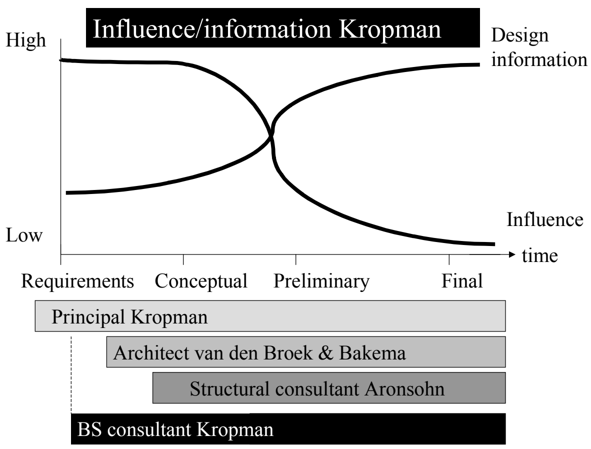
Preservation of energy resources and environmental impact limitation are key issues of modern architecture. Sustainable building will be the major guiding principle for renewal of building and spatial planning practice. In current building practice sustainable energy systems are often treated like an add-on component to the already completed building design. This is seen as the main cause of the poor use of sustainable energy in general. In order to overcome this problem the building industry has identified a need to better integrate sustainable energy systems in buildings. A specific approach for building design is being developed, which should lead to successful design and optimisation of sustainable energy components – and therefore their wider and more appropriate use. Moreover, synergy between sustainable energy components with construction and HVAC-systems will be achieved.

The basis of this new approach is “thinking in levels”, in which the design and decision processes are improved by structuring them at different levels of abstraction. At each level in the design process different decisions have to be taken. One of those decisions is the application of sustainable energy systems and components. In present situation they are rather complex to integrate in the building design. It is important to mention here that (building) design is a creative process based on iteration: it consists of continuous back-and-forth movements as the designer selects from a pool of available components and control options to synthesize the solution within given constraints. At the early design stages, usually only conceptual sketches and schematics are available, often rough and incomplete. As the design proceeds, more information and detail will be developed. However, even though during the early design stages little information is available nearly all the important decisions have to be made.



The figure on left shows this contradiction between available information and actual influence on the design during its development [3]. The decision on use of sustainable energy systems and components is therefore usually postponed or ill-founded taken, resulting later in sub optimal solutions and often leading to complete rejection of proposals. In the designing of the new office for one of the major Dutch mechanical and electrical contractors, Kropman, this has been avoided.

The office had to be innovative, with flexible construction and notable use of sustainable energy [1]. In order to make this possible, the design process itself was also a topic of study. The studies of the students on specific building aspects led to new understandings that were used in the conceptual design phase, resulting in a more fundamental insight into the information flow in the design process.



The figure on left shows the difference in 'actual influence' / 'available information' relation within the Kropman project. As principal of their own office, Kropman used the design process to investigate the influence of introducing knowledge of building services consultants into the early conceptual stages of the design process. Furthermore, even at the requirements stage of the design process the influence of the building services consultant could be effective.

The realized building reached the status of a demonstration project within the IFD (Industrial Flexible Demountable) programme of SEV (Stichting Experimentele Volkshuisvesting), by application of new innovatieve construction products and methods [2]. However, for better integration of sustainable energy solutions with the construction of the building, genuine added value and decrease of project risks, further improvement of the early, conceptual stage in the design process is needed.

Besides designing the Kropman project, one of the design team members was chairman of the steering committee Climate technology of the TVVL (Dutch Society for Building Services). During this period he was asked questions about the investigation of problems concerning comfort and health in buildings. Instead of treating them with an 'end of pipe solution' approach, where only the effect is treated and not the cause, the real source of the problems was investigated. These problems resulted from mistakes made during the design process, so it was logical to investigate the design process itself. The parallel between the activities within the Kropman design process and the TVVL activities led to a combined effort. The architect and building services consultant of the Kropman project took the initiative to get in touch with the Royal Institute of Dutch Architects (BNA) and Delft University of Technology (TUD). In year 2000, BNA, TVVL and TUD participated in the research project Integral Design. This project primarily aimed at the reduction of failure costs. The idea of the participants was that, by optimising the design process, fewer mistakes will occur and fewer unnecessary costs will arise. The project had to unfold ways to investigate and implement an integral approach for building design. This integral approach encompasses the built environment from initiative to design, construction and real estate management as a seamless whole. This seems to contradict with the subdivision of the construction industry in phases, in which parties operate with opposing interests, resulting in disintegration and waste. The coordination of these independent phases, scales, decision-makings and disciplines are crucial to the creation of a built environment in which the people concerned feel comfortable. This is the core of the integral approach. Integral design is meant to overcome, during design team cooperation, the difficulties raised with the early involvement of consultants. This is achieved by providing methods to communicate the consequences of design steps between the different disciplines on areas such as construction, costs, life cycle and indoor climate at early design stages. The aim is to support all disciplines with information about the tasks and decisions of the other disciplines. Supplying explanation of this information will improve understanding of the combined efforts [3].

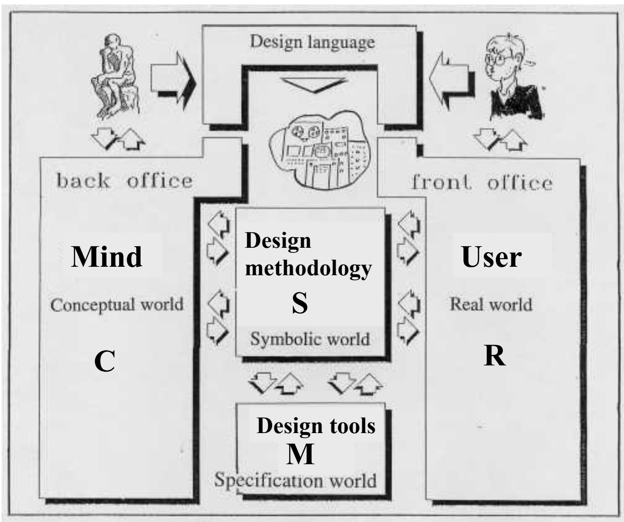
METHODS

When attempting to integrate sustainable energy into design decision-making, the process must identify its opportunities. This can be achieved with use of abstraction, by isolating those aspects of a problem that are important for a given design question and suppressing the unimportant ones [4]. The result is an appropriate (abstract) representation that matches the needs of design specialists, without overloading them with unwanted details. The various levels of abstraction should be considered as representations of a particular view on the total information available for a design.

The integrated design model must therefore: (1) be able to distinct related information, (2) support distinctions related to the different levels of abstractions (views) by being structured into corresponding sub-models, and (3) ensure the satisfaction of consistency and completeness of constraints linking different levels of abstraction in the design process. Design is viewed as a problem-solving activity in which functional reasoning is central. To develop our model of design support, the existing model from the mechanical engineering domain, Methodical Design [5, 6, 7], was extended from three to four main phases. Within those phases eight levels/stages of functional hierarchical abstraction can be distinguished, similar to system theory:

System Theory	Activity phase	Extended Methodical Design
Definition Demands	Generate	Problem definition
Synthesize Analyze	Synthesize	Working principle
Evaluation Decision	Select	Detail design
Implementation Application	Shape	Realisation

The occurrence of a four-step pattern of activities in each stage is model's main feature. Complex design tasks can be decomposed into problems of manageable size, based on building component functions. This functional decomposition is carried out hierarchically so that the structure is partitioned into sets of functional subsystems. Through this classification the proposed possible solutions are also easily further surveyed.



Separation is made between:
- information level, knowledge-oriented, representing "Co-nceptual world",
- process level, process oriented, representing "Symbolic world",
- component level, device oriented, representing "Real world", and
- part level, paraMetric oriented, representing "specification world".

Communication between architect and building services consultants is based on the transformation from the conceptual world to the real world, [8, 9]; i.e. the exchange of abstract descriptions of a design as shown in the picture above.

Information Level

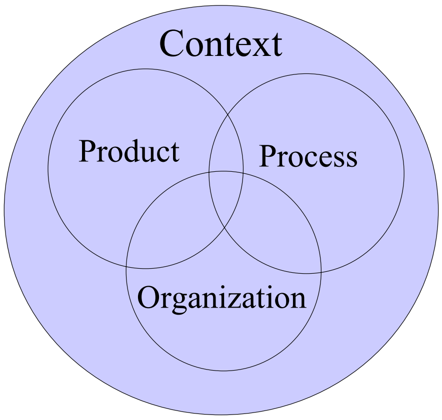
This level deals with the knowledge of the systems by experts. One of the essential ideas behind this is that human intelligence has the capability of search and the possibility to redirect search. This information processing is based on prior design knowledge. One of the major problems in modelling design knowledge is in finding an appropriate set of concepts that the knowledge should refer to, or -in more fashionable terms- ontology.

Process Level
This level deals with physical variables, parameters and processes. The set of processes collectively determines the functionality of the variables that represent the device properties. Modelling at the functional level involves the derivation of an abstract description of a product purely in terms of its functionality. This abstraction reduces the complexity of engineering design to the specification of the product's desired functionality.

Component Level
This level describes the hierarchical decomposition of the model in terms of functional components and is domain dependent. Generic components represent behaviours that are known to be physically realisable. They are generic in the sense that each component stands for a range of alternative realisations. This also implies that the generic components still have to be given their actual shape.

Part Level
This level describes the actual shape and specific parameters of the parts of which the components exist. Relevant technical or physical limitations manifest themselves in the values of a specific set of parameters belonging to the generic components. These parameters are used to get a rough impression, at the current level of abstraction, of the consequences of certain design choices for the final result.

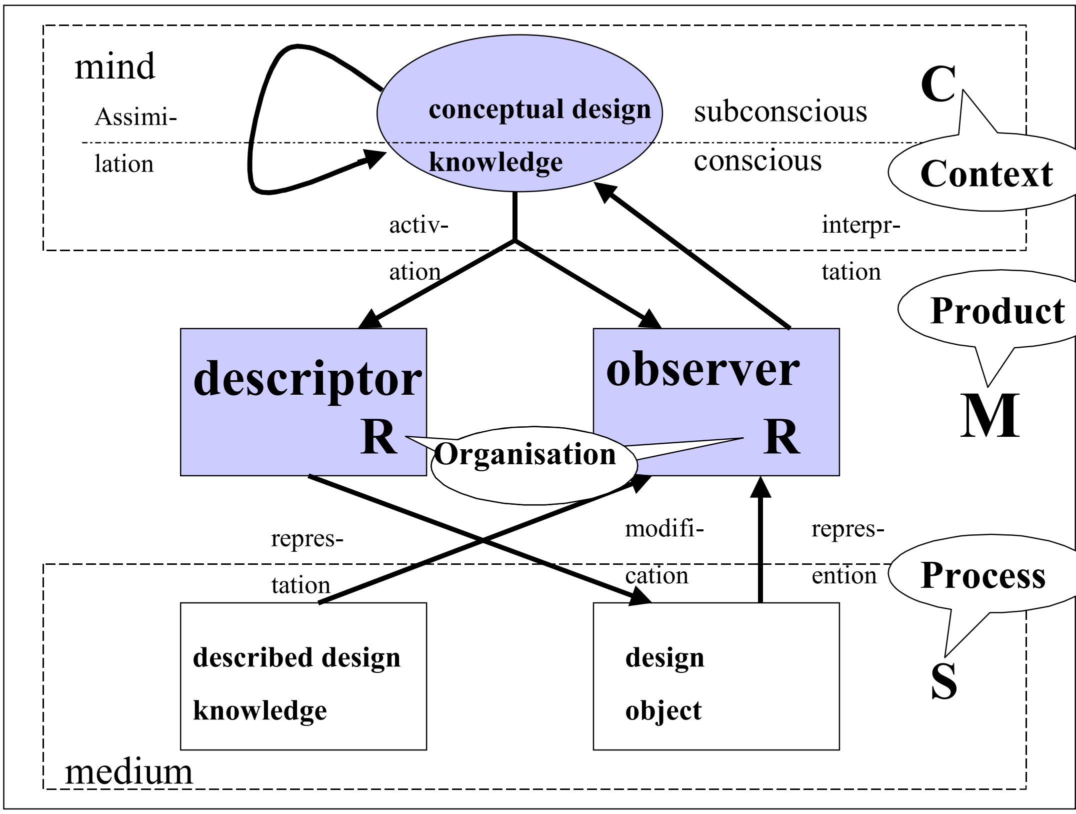
Communication / designing takes place in an environment that influences the process; it is contextually situated [10, 11].



The context of the model of designing is defined by a "world view".
The Product – Process – Organization model (shown left), developed by Friedl [12] is used as a representation of this "world view".
Friedl's PPO model discerns four essential domains of concern in the design situation:
- 'product domain'
- 'process domain'
- 'organization domain'
- 'context domain'

The dynamics of these domains are the parts that form the life cycle of the design situation.

The overall representation of our extended model, based on the explained theoretical basis, is summarized by the next figure:



Problems emanate from a lack of integration between architectural design and design of the indoor climate. Building Services consultants have difficulties adapting their methodical and arithmetical way of working to artistic and intuitive characteristics of architectural design. To a slightly lesser degree, the same applies to structural consultants. This notion of 'professional enmity' is not as insurmountable as it may seem [3]. To work effectively with methodology, the insight should grow that it is not the building that should be central in the design, but the needs of the humans for which the building is intended. This leads to a new way of looking on the ‘world view’ in which the human needs are the key aspects that have to be met.

Interactions during the design processes were studied during Integral Design research project in different workshop settings with experienced professionals from the TVVL and BNA [13].

Workshop 1, October 2001, expert multidiscipline participation:
Some of the leading Dutch architects and building service consultants participated and worked together in four groups of six disciplines. After working on the conceptual design the teams had to pass their results to another group, which had to continue working on the design. Each group’s actions were observed during the two sessions. The results were evaluated in a separate session with the participating experts.

Workshop 2, January 2002, monodisciplinary:

The focus was on interpretation of different aspects of the design process from the point of view of 26 participating building service consultants, in order to come to ideas and suggestions for improvement of the current situation.

Workshop 3, September/ October 2002, combined design teams BNA-TVVL:
The architect acted as building service consultant and vice versa. More than 120 professionals participated and the results were evaluated by the students. Each group had two observers who wrote down the actions during the design sessions.
This project was followed by two KCBS workshops [14, 15] as a part of a PhD-research. The new approach is characterized by supportive methodological elements to stimulate multi-disciplinary project and product development, especially the use of sustainable energy solutions. A tool from methodical design was introduced: the morphological scheme. Subfunctions and solutions are presented in a framework of columns and rows. Each combination of solutions chosen at the various levels of sub functions makes a structure that represents a solution for the overall function to be performed. In the first KCBS workshop, groups of two architects together with one structural and one building services consultant worked together. In the second workshop only one architect was part of the group.

DISCUSSION OF RESULTS
The results we have so far achieved during these workshops will be used in further development of design sessions. In order to allow a stepwise approach in which each design decision has well defined implications, four distinguished levels (information, process, component and parametric level) provide a good structured framework for the use of morphological schemes.

When verifying a new methodological concept, it is not common to work with experienced designers from different disciplines. This is mostly done by experiments with student groups [16] or with design groups within one company [7]. However, the relevance of research for the daily design practice improves by using experienced designers, as there is a major difference in approach between novice and experienced designers [17, 18].

Building service consultants have pointed out during 2nd workshops that they want to be more involved in design processes during earlier stages. They argue that this way some problems further down the road could be avoided. This is something we also encountered with other disciplines during different design sessions and from various questionnaires. But, during the same design sessions we have discovered that it’s not easy for them to fulfil the requirements in those new situations. The role change, which was introduced during 3rd workshop series to tackle this problem, doesn’t seem to help in adjusting the way of their thinking and acting. The positive thing was that it did help to increase the awareness of the existing situation. The last two workshops have also shown that the number of representatives from certain discipline doesn’t have significant influence on the process, as long as all disciplines stay involved.

To support design teams more effectively in their tasks, integral design methodology for conceptual design proves to be promising. This is mainly based on the reactions of the participants in the workshops, whose reflections show the increase in cooperation and synergy between design team members.

CONCLUSIONS

The first hard conclusion is that workshop formula needs to be further developed. For example, the sessions need much more time in order to be more effective. It is rather difficult for participants to understand the methodology, use it in order to firstly understand each other, understand the design questions put upon them, find an integral solution, present it and evaluate this everything in only one halve day.
However, we can make some statements concerning the results achieved so far.
The need for an integral approach in designing a building and its services systems is strongly felt by all participants. This is a very important conclusion, because it makes further efforts to construct a bridge between architecture and building services relevant. By carrying out research for this methodology in close cooperation with experienced designers from different domains, the chance of bridging the gap between design theory and daily practice will truly become reality increases. In addition, it will be possible to supply information about sustainable energy applications at a much earlier stage in the design process. And, since this stage precedes the points where most decision-making takes place, these applications will have a much better chance of actually being implemented.

ACKNOWLEDGEMENTS

TVVL, BNA and TU Delft have supported the Integral Design project. KCBS, Kropman bv and the foundation “Stichting Promotie Installatietechniek (PIT)” support the new research.

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EARTH, WIND AND FIRE
TOWARDS NEW CONCEPTS FOR CLIMATE CONTROL IN BUILDINGS

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Abstract
The Earth, Wind and Fire concept means letting nature do its work in controlling the interior climate of buildings. It reduces the need for HVAC technology, minimizes energy consumption and boosts workplace productivity. Since about 1900, architects have gradually lost the art of designing buildings as *'machines'* for climate control. Climate engineers remain fixated on HVAC systems. This trend will have to be interrupted if we are to achieve integrated designing of buildings plus their interior environment. To break out of the trend, it is essential to have a reliable common base of knowledge, expertise and understanding. This common base, identified metaphorically as a *'Grammar of Integrated Design'* (henceforth *Grammar. I.D.*), will be developed in a research titled 'Earth, Wind and Fire'. The knowledge gained will enable architects to play a significant artistic and intellectual part in creating a sustainable built environment. The study comprises the analysis, exploration of design alternatives, modeling and validation of various techniques that will let nature do its work again in a building. Principles and variants of the architectural design will be investigated by architectural students.

Keywords: Climate-control, natural, sun, ventilation, wind.

INTRODUCTION
The researcher is an experienced consulting engineer in building services, who has worked with many architects and knows this professional group well. Since many years he is also coaching, advising and assisting MSc students at the faculty of architecture. He observed that generally students, just like architects, dislike mechanical systems and often present quite surprising and sometimes amazing proposals for a more natural way of climate control. The exercise *Dream and Realization* of the chair *Constructional Integration and Coordination* appeared to be a breeding place for many fantastic ideas. The *Dreams* come from the students but the question if *Realization* is feasible has to be answered by the indoor climate consultant. The problem is that in many cases the consultant does not know how to answer these questions and also misses the tools for that; this problem is the immediate cause of the research program *Earth,* Wind *& Fire*.

The researcher wants to combine his knowledge, experience and power to draw up a *Grammar I.D.* which is intended to answer questions like these for the benefit of students, architects, the building industry and the environment. The study will be carried out as doctoral research. So, this paper does not give solutions. It is intended to check if the right questions are asked, to gain the view of CIB experts to the problem as stated above, and to gather information on the state of the art in this field worldwide.

Building services have developed during the last 150 years to become a dominating factor in the built environment. All over the world, electromechanical services in buildings provide a comfortable, productive indoor environment, as well as hygiene, security, lighting and communications. Compared to past times, architects have won a much greater design freedom, and have accordingly changed the look of our world. On the downside, electromechanical services place a heavy burden on the available energy, raw materials and financial resources. They have made society dependent and have made buildings more complicated. Is this trend reversible, and if so, how can that reversal be brought about?

DEVELOPMENT OF BUILDING SERVICE TECHNOLOGY

Building services systems as they are now have developed over about 150 years, roughly from 1850 to 2000. The main technical advances in this area took place in the latter half of the 19th century. Climate control, or HVAC, is the building service that has done most to change the building world and architecture. For centuries, the architecture of a building was carefully gauged to the location. For centuries, too, buildings were carefully designed to allow the admission of light and air, and to repel or admit solar heat as appropriate. The development of technical systems made all these considerations superfluous. Electrical and mechanical equipment made buildings independent of nature and assured an unprecedented level of comfort. These systems also greatly enlarged the design freedom of architects, who have accordingly taken full advantage of them. The disadvantage has been that buildings have become wholly dependent on their electromechanical systems. They can no longer function without building services technology.

DEVELOPMENT OF BUILDING SERVICES TECHNOLOGY IN THE 20th CENTURY

The development of building services has meant an increase in the costs allocated to technology. Figure 1 represents the development of these costs over time. The building services costs in well-equipped office buildings have increased by a factor of 10 in 100 years. All kinds of technical systems have contributed to this development, but the cost of climate control systems (Health, Comfort and Hygiene) clearly dominates.

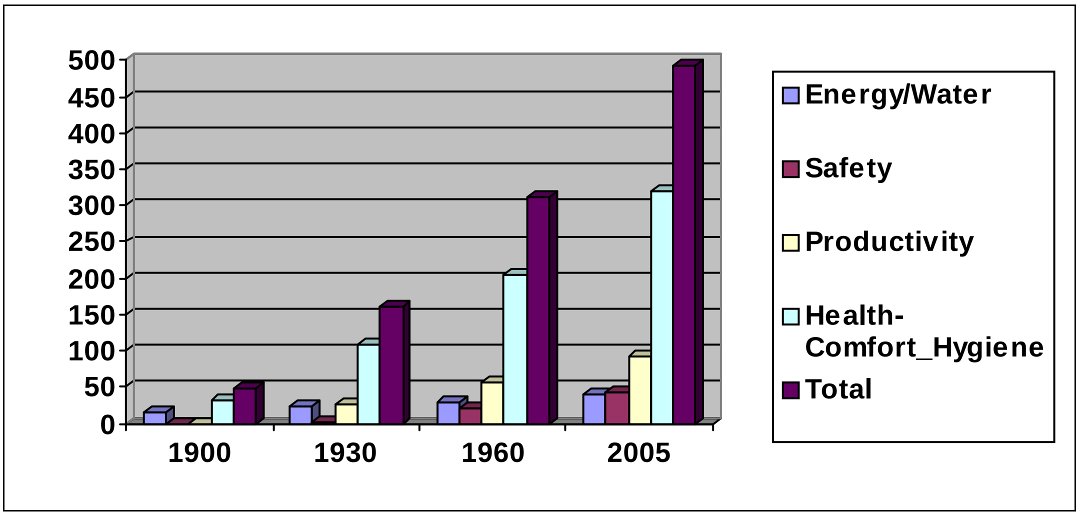


Figure 1 Building service costs in office buildings 1900-2005 in €/m^2_{gfa} (excl. VAT)

REASONS TO EXPECT A TREND TOWARDS MORE INSTALLED BUILDING SERVICES TECHNOLOGY IN THE 21st CENTURY

There are some ongoing developments which give grounds to expect further rise in the level of installed building services, for example:

- Architecture is using increasingly exuberant forms and masses, a trend not unconnected with increasing prosperity. Building services are increasingly necessary to obtain a satisfactory indoor environment in these buildings.
- Some areas of the world (for instance the Netherlands) experience an increasing shortage of building land. This fuels a trend towards taller buildings, building underground, building on water and multiple land utilization. Building services play an important part in such buildings.
- In buildings of the above kind, which have lost direct touch with the natural environment, increasingly high standards will be required for the indoor environment.
- The rising use of communication technology will entail enhanced technical facilities in buildings.
- The demand for luxury and comfort will increase.
- More mechanical ventilation will be needed in metropolitan and traffic-dominated situations because the poor quality of the outdoor air often makes natural ventilation undesirable.

REASONS TO EXPECT A TREND TOWARDS LESS INSTALLED BUILDING SERVICES TECHNOLOGY IN THE 21st CENTURY

On the other hand, developments have been noted pointing towards a lower level of installed services. Some examples are:

- Architecture is showing a perceptible trend towards controlling the indoor environment in a more natural way, with more reliance on natural daylight and natural ventilation.
- The integrated design of buildings and their indoor environment will reinforce the above trend.
- Sustainability is becoming an increasingly prominent political and social issue. Experimentation with low technology buildings, low energy and passive buildings is taking place worldwide.
- In the future, achieving a lower energy consumption in buildings will not be enough. Buildings will have to become at least energy neutral, and in the long run will have to become net suppliers of energy.

TOWARDS ENERGY NEUTRAL BUILDINGS

Buildings and climate control systems are normally designed separately rather than integrally, with the result that substantial HVAC installations are needed to create an acceptable indoor environment. The side effects of this are a suboptimal quality of the building, high failure costs in the building process, a high energy consumption for climate control, high running costs and a short building life span. This situation will not change as long as architecture and climate engineering remain strictly separate domains. A different outlook on the design process is required, an outlook in which the conceptual distance between the architect and the climate engineer is reduced and they have confidence in each other's professional field.

The architect, with all his creativity and his influence on the building process, is largely uninvolved when it comes to matters of energy and the indoor climate. He must be persuaded to become a partner in the climate system design. As a technical and artistical co-designer of the climate system, he has an opportunity to excel in this area, thereby bringing to bear an unprecedented level of intellectual and artistic potential. Turning the building itself into a machine for climate control will allow the installed systems to remain simple and robust.

The climate engineer generally has a strong focus on the proper functioning of the installed systems. He sees them as independent elements and has little concept of the usefulness and necessity of integrating and coordinating all the building components into a single built whole, and of the potential beauty of that whole (Verheijen 2002). The climate engineer is not trained for that and lacks the requisite knowledge and tools. To change this situation, a common base of knowledge, skill and understanding is needed. This is the objective of the Earth, Wind and Fire study. The direct utilization of natural elements for climate control brings the architect back to one of the fundamental aspects of his profession. For the climate engineer, it holds out a challenge to practice his profession at a higher level. The architect and the climate engineer will eventually be capable of designing architecture and the indoor climate in a truly integrated manner. This approach is a serious necessity in trying to achieve an energy neutral building. It will also substantially reduce failure costs in the building process, with their inherent and undesired consequences for the environment.

THE STATUS QUO IN 2005

Architects will probably need relatively little inducement to stop restricting themselves to shapes and masses and instead to put effort to optimizing the passive climate control of their designs. Proof of this is provided by the widely expressed admiration and appreciation of work by certain international architectural celebrities who have gained a name in this area. Buildings designed this way adapt to their natural context. The sun and wind are utilized as natural phenomena to obtain an optimal indoor environment, and in some cases the ground is coupled interactively to the building mass. Electromechanical equipment is avoided as much as possible; i.e. first class integration (Luscuere 1992).

These buildings not infrequently cut across conventional boundaries, sometimes with striking results. Most of them have a ‘green image’, promise a lower energy consumption and offer an improved indoor climate. They often engage with a widespread public distrust of air conditioning. But are these buildings really all that good? This question arises because media publications pay considerable attention to the design but very little to the energy consumption and other performance aspects of such buildings. The scientific basis of these designs is moreover often unavailable. Information about generic design methods or a design methodology cannot be extracted from the publications concerned, with the result that they remain incidental architectural performances. When design tools such as simulation and/or CFD analysis have apparently been used to put the architect’s intuitive design to the test, these tools are in most cases specific, highly specialized software applications. The essential research question to be addressed is as follows: Design a Grammar. I.D. which architects and climate engineers can use as a basis for the conceptual design of *“performative architecture”*. Once such a grammar is available, it will surely become possible to persuade climate engineers to abandon their fixation on fans, pumps, pipes and air ducts, and to devote their attention to climate control at a higher level.

NATURAL VENTILATION: DICHOTOMY OF THERMAL COMFORT OR PRODUCTIVITY

Applying natural ventilation is an important means towards energy neutral buildings. During hot summer weather, however, naturally ventilated buildings without cooling generally fail to satisfy objective comfort criteria as established by the PMV (predicted mean vote) model for thermal comfort (Fanger 1970, ISO 1994). An extensive, worldwide study has demonstrated that people are often more tolerant towards the spatial conditions in which they work than would be expected from calculations based on the thermo physiological model of ISO 7730. Considerable differences are however observed between individual buildings.

Buildings with a central climate control and non-operable windows give people few options for adjusting their environment, and their tolerance towards the indoor climate proves much smaller under these conditions than in naturally ventilated buildings without cooling. Expectations undeniably play a part in this effect. In naturally ventilated buildings where people can exert a greater influence on their thermal surroundings, the spread of acceptable space temperatures is much wider, and substantially exceeds the comfort limits defined in ISO 7730. Only 50% of this spread can be explained by the difference between the space temperature and the outdoor temperature, by clothing and by the relative air velocity in the interior. The rest of the spread must be ascribed to physiological and psychological adaptation processes which alter the *'set point'* of subjective thermal comfort.

Greater tolerances in the air temperature may thus be acceptable from a thermal viewpoint, but in combination with high air humidity they may exert a negative influence on people's labour productivity, as shown by studies carried out by Fanger and co-researchers. The enthalpy of the interior air proves to have a significant influence on the perceived air quality, which in turn affects productivity. *"Serve the ventilation air cool and dry, lower the ventilation capacity, raise productivity and save energy"*. That in short is Fangers' maxim for the 21st century. Toleration of a high room temperature, which could potentially yield a lower energy consumption and lower investment costs for climate control, must thus be paid for with lower productivity. It ought to be possible to combine the best of both worlds: a naturally ventilated building in which the ventilation air can nonetheless be supplied in cool, dry form. The Earth, Wind & Fire research aims to investigate the feasibility of a climate control system that meets this aim.

RESEARCH QUESTIONS

Earth

The earth is an almost inexhaustible source of heat and cold. When actively coupled to the building mass, it can provide heat to the building in wintertime and cooling in summertime. Thermal activation of the building mass, or slab activation, has become popular in some countries. The earth is also a constant source of gravitational force, which can actuate air currents required for natural ventilation.
Research issues are (see Figure 3):

- How to heat up and possibly humidify the ventilation air in wintertime at the very low pressure losses typical for natural ventilation systems?

- How to cool and possibly dry the ventilation air in summertime in order to improve the indoor environment quality and obtain the required negative stack effect?
- Which pitfalls regarding moisture and condensation can be expected if natural ventilation is applied in a cooled building?
- How can gravitation be used for the transport of ventilation air? What are the psychometric, hydraulic and energetic properties and design criteria for vertical cooling washers?
- Is it possible and feasible to collect rainwater and to utilize it in a vertical cooling washer for conditioning the ventilation air?

Wind

As the wind speed increases with the height above the ground, the wind pressure on the top of buildings can be considerable, especially on high rise buildings. The research comprises the following issues (see figure 2):

- How can we make use of this effect by catching the wind at this level and duct it into the building at various wind directions?
- How will this approach influence the design of roofs? What can we learn from airplane wings?
- What are design criteria for roof hoods or special roof structures? Can commercial available wind catchers be useful?
- How much wind pressure is attainable for conditioning the air, taking into consideration the wind rose at the various location?
- How can negative wind pressure be used for air extraction, for example using cowls or special roof structures?
- Is it possible and feasible to use the ventilation system to generate wind energy, for example outside office hours and in periods of strong winds?
- What does this imply for the orientation of buildings?

Fire

The sun, like the wind, is an inexhaustible source of energy, but in office buildings solar heat is mostly kept outside as much as possible. Because of the high-quality insulation and the internal loads, solar heat has often to be dissipated by cooling, even in wintertime. Nevertheless, buildings receive an enormous amount of solar energy, which should be captured and used. Research issues are (see figure 4):

- How can solar heating be utilized to provide the natural draught for extraction of the ventilation air?
- Which are the design criteria for solar chimneys in buildings?
- What role could these solar chimneys play as thermal sources for heating a building during the heating season?
- What is the performance of combined wind and sun ventilation systems taking into consideration their simultaneousness based upon weather data?
- What does this imply for the orientation of buildings and the design of façades?
- What are the implications for the architectonic design of buildings?

General

Natural ventilation in the Earth, Wind & Fire concept operates at very low pressures. As a consequence the size of the channels has to be increased compared to mechanical systems with sheet metal ducts. It is obvious to integrate the channels in the building design making them part of the construction. Research issues are:

- What does this imply for the architectonic design of buildings?
- What is the impact on the life cycle of buildings, financial and environmental?

The Earth, Wind & Fire concept uses mainly natural elements but, as these vary in time and power, supporting electromechanical and control systems will be necessary to fulfil the requirements of the indoor environment. This raises the following research issues:

- Which supporting electromechanical and control systems are necessary?

ENERGY AND SUSTAINABILITY

In the search for an energy-neutral building, the potential contribution of the Earth, Wind & Fire concept may be broadly quantified as follows:

- Reduction of energy consumption for heating through the use of heat pumps together with ground buffering and solar chimneys as heat sources and building components for heat delivery. The small temperature differential makes a heat factor in the region of 10 possible, so that the heat consumption on the basis of primary energy can be reduced to about 10 percent in comparison to a central heating boiler.
- The Earth, Wind & Fire concept makes use of natural ventilation, so that the ventilating fan power consumption is reduced to practically zero. Only the pump power requirement will increase, to a limited extent.
- The ventilation air and thus the building are cooled using cold stored in the ground, for which no external energy is required. Only the pump power requirement will increase, to a limited extent. Below I assume a residual consumption of 20% compared to the traditional situation.

Consider an office building with full climate control. The gas consumption is 10 m^3 per m^2 and the electric power consumed by HVAC equipment is 70 kWh/m^2.a. The energy consumption data before and after introduction of the Earth, Wind & Fire concept are as follows:

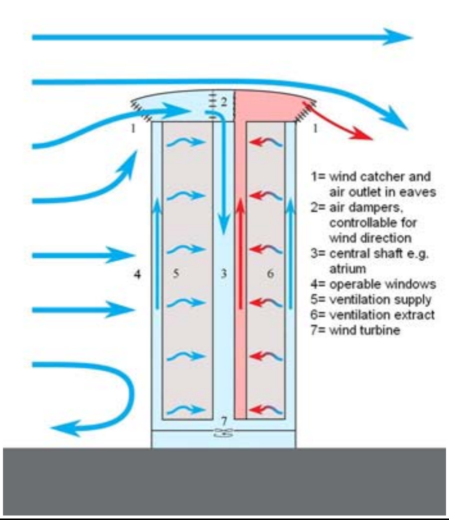
Energy MJ/m^2.a	Traditional		Earth, Wind & Fire	
	Primary energy	Final energy	Primary energy	Final energy
Gas	350 (: 1,4 =)	250	0	0
Electricity	210 (: 3,0 =)	70	42 (:3,0=)	14
Heat pump	0	0	75 (:3,0=)	25
Sun and wind active[1]	0	0	117 -/-	
Total	560		0	Energy neutral

The effective energy saving of (560-117=) 443 MJ/m2.a is equivalent to approx. 80%. It will therefore be considerably easier to generate the remaining electrical energy requirement from renewable sources. The study will include a broad survey of the potential opportunities for this at building level and at district level.

[1] Active heat and power generation is not the main purpose of the study but will be regarded sidewardly.

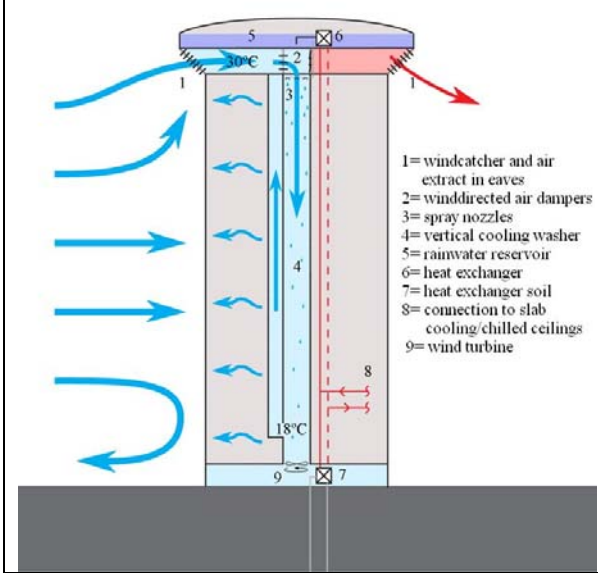
EARTH, WIND & FIRE – PRINCIPLES

The following figures illustrate the Earth, Wind & Fire concept in terms of a number of principles which will be addressed in the research.



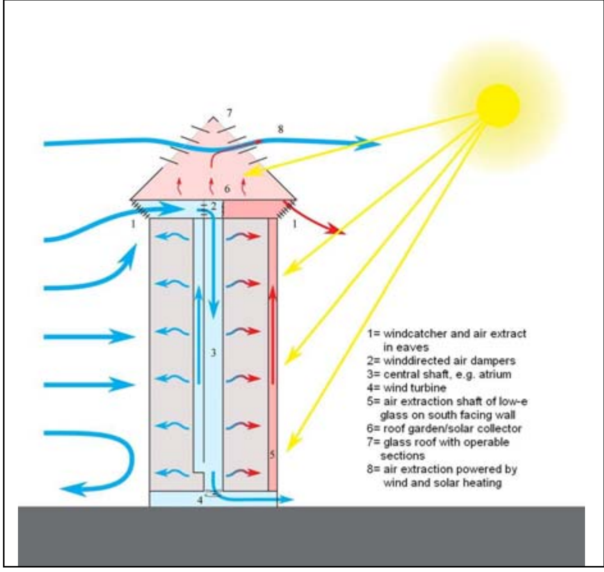
- The roof is carried out as windcatcher. The ventilation air flows through a central vertical shaft downwards, and is distributed at the foot e.g. via an atrium.
- At outdoor temperatures below the room temperature the shaft operates as a reverse chimney, providing additional pressure.
- Air dampers are operated to adjust the system to any wind direction.
- The ventilation air is extracted to the roof plenum and removed at the leeside
- The excess air is removed to the leeside through a wind turbine
- Additional low pressure filters (electrostatic) and heating is possible
- For operation in summer see figure 2

Figure 2 – Wind driven natural ventilation



- Starting point is an indoor temperature of app. 25^{0}C, to be realized by slab cooling.
- The roof is designed to function as a wind catcher. The ventilation air flows downwards through a central shaft, from where it is distributed through the building, e.g. via an atrium.
- The central shaft operates as a reversed stack which is carried out as vertical cooling washer.
- At the top cooled water is sprayed into the washer, as a result of which the warm outdoor air is cooled and dried.
- By the combined effects of cooling and induction of the falling water the ventilation air flows downwards.
- The feasibility to collect rainwater and use it as spray water will be investigated.
- Slab cooling and cooling of the spray water is done with cooling from the soil.

Figure 3 – Wind- and thermal driven ventilation in summertime



- The roof is designed to function as a wind catcher. See figure 3
- When the outdoor temperature is lower than the interior space temperature, the shaft operates as a reverse chimney, thereby supplying additional pressure.
- Air dampers are operated to adjust the system to any wind direction.
- The ventilation air is extracted to the roof plenum and removed at the leeside.
- Surplus air is transported to the lee side by a wind turbine.
- Electrostatic filters and heating can be incorporated.
- The above-roof solar chimney can be designed as a roof garden.

Figure 4 – Wind- and thermal driven ventilation + solar chimney with roof garden

THE RESEARCH

The research will be carried out in 3 phases:

1. Theoretical and analytical phase (2005-2006)
2. Development of software for simulation and modeling by experts from the Eindhoven university of technology (2006-2007)
3. Validation of the software by measuring and testing in physical scale models in a laboratory (2007- 2008)

The research will be guided by a group of prominent Dutch architects and engineers from the building- and the building services industry.

Financial support is requested from SenterNovem, the Dutch governmental agency for energy research.

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OPEN BUILDING: AN ARCHITECTURAL MANAGEMENT PARADIGM FOR HOSPITAL ARCHITECTURE

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Abstract
This paper discusses a significant and innovative architectural management method, used for the first time in a medical facility under construction in Bern, Switzerland. The 50,000 square meter project – the INO - is being managed by the Canton Bern Building Department. The client and the management team recognized - when the decision was made to build a major addition - that complex buildings such as this only become "whole" over time. They had come to realize, after many conventionally procured buildings, that inevitably the program of functions changes to meet new medical procedures, new regulations, and new market and insurance conditions. Recognizing these dynamics led to a decision to adopt an entirely new process for procuring the facility, and with it a concept of distributed design management. A competition was held to select a design and construction firm for each of three distinct "levels". The primary level is intended to last 100 years and is expected to provide capacity for a changing mix of functions. The secondary level is intended to be useful for 20+ years, and the tertiary level for 5-10 years. The approach discussed in this paper deals in a new way with problems of facilities change, and the concomitant management of distributed design and construction responsibilities. As such, it represents a good example of "open building" theory and practice, an approach to facilities design and construction that is conventional in the office and shopping centre markets and increasingly in multi-family residential construction worldwide. The INO project is the first known project to apply these principles of architectural management in health care architecture. It therefore sets a new standard for adaptable medical facilities, offering an alternative paradigm to meeting critical needs in the field of health care architecture.

Keywords: Design, open building, hospital.

BACKGROUND

In the past three decades (Prins et al 1993; Brand 1994; Templemans Plat 1995; Kendall October 1999, Venturi and Scott Brown, 2004), facility managers and clients of commercial and office buildings in many countries have come to understand that dynamic societies require agile architecture. Two alternatives face clients with dynamic requirements:

1. Scrap and build practices – design and construction according to presumably "fixed" programmatic requirements, resulting in facilities requiring expensive renovation when uses change and entangled systems must be upgraded, or premature demolition when economical upgrading is impossible.

2. Stock maintenance practices – design and construction according to analysis of both current requirements and provision for unknown future uses and technical upgrading. This is called "open building" among some practitioners internationally.

There is new evidence that "stock maintenance" practices are being applied with increasing frequency to the medical facilities. A sharp departure from conventional functionalist thinking and architectural management practices is increasingly recognized as a prerequisite to deliver sustainable built facilities of the scale, quality and capacity called for in the medical campus of tomorrow. Designers, facility managers and medical facility administrators are slowly adopting new ways of working. The evidence of this is ubiquitous, but not easy to name or recognize from the perspective of the management thinking in which we have been trained to operate. This paper reports on a project that may be among the first in the world to apply "open building" management principles to the design of a large medical complex. But before introducing the project, it is useful to review a number of principles and problems facing health care architecture.

Basic Principles of the Behaviour of Complex Environments

The "open building" strategy for architectural management, discussed in this paper, has its roots in the way ordinary built environments behave. An example helps to illustrate the point. Most cities have developed, spread out, declined, renewed in parts, refocused their sense of place and have become multi-nucleated. In all of this, the city is an example of a fine-grained "living fabric". Not surprisingly, no one party – private or public - controls the whole. Only a few owners – universities, medical centres, large corporate organizations, and governmental units being the most prominent – are large-scale, but even in these cases, control is hierarchically structured within them.

Most cities and towns are representative of hierarchical organization. The city owns and maintains the streets and the city utilities, and mandates and enforces building regulations and zoning ordinances. Individual families and companies own individual lots on which they construct buildings. Some of the buildings are occupied by tenants who independently fit-out their own spaces to meet their preferences. There are systemic principles at work, even if they are not appreciated or are largely invisible at any given time.

This living fabric regenerates itself naturally and regularly, if unevenly. There is a certain order to the process. Parts can be replaced without excessively disturbing other parts. That is, buildings can be demolished and replaced by others without disturbing adjacent buildings or the street network. This is possible because all parties involved follow accepted conventions or rules, in which it is in everyone's interest to expand their own territory as far as possible, express their own values and use personal resources conservatively in doing so, while avoiding conflict. In a healthy living fabric there are no winners or losers, but rather a dynamic balance in time. There is a definite hierarchy at work that helps us manage change. The larger framework of streets sets the context for the properties on which individual buildings are constructed. We have experiences that show us that if the street network adjusts, the buildings situated in the spaces between the streets are affected. But the buildings can adjust without impacting the street network.

Lessons for Hospital Facilities Clients

This hierarchical structuring helps us to manage complexity. It also allows distribution of responsibility with minimal fuss and conflict. Some of the buildings we appreciate most – those most suited to agile regeneration - were, not surprisingly, organized in congruence with this hierarchical structuring. Constructed in the 19th century in the pre-functionalist or pre-Modernist period (Brand 1994, Venturi 2004), these are among the buildings that are being saved and renewed today and used as models for new work.

The reason they are being adapted is not first of all because of their style, although now we seem to want to preserve these historic buildings because the public, clients – and many professionals – doubt the current profession's capability to deliver better buildings. Built by one party and one architect one hundred years ago, they are now being adapted by other architects for new uses.

These buildings are models of the kind of buildings hospital administrators are increasingly expecting from their architects and engineering consultants. Not only do they fit into a coherent urban pattern, they are simple to build and offer spaces of remarkable quality, as well as spatial and technical capacity. Most important, they are not tightly integrated with programs of use – they are not defined "functionally". They are "open" buildings, sustainable in the large sense because they can accommodate change.

The Insel Hospital and the INO Addition

Figure 1: Part of the Insel University Hospital Campus in Bern

One such departure from the norm was the decision to construct a large 50,000 sq meter medical facility on the Insel teaching hospital campus in Bern, Switzerland, part of which can be seen in Figure 1. As with all medical facilities, this project was planned under tight budgetary, regulatory and environmental constraints. The story of this project is worth recounting since it represents the decision of a large client and its facility planners to alter the management methods it had been using for decades, in order to obtain a new facility to meet the future with more assurance. (Building Futures Institute 2002).

The Insel Hospital is a hospital for intensive care, emergency and surgery. For several years, the facilities planning group of the Canton Bern building department, responsible for this major primary health care facility, tried to fix a program of uses so that a design team could produce construction documents for a major addition, called the INO. Each year, a series of events occurred that prevented them from fixing the program: new medical procedures were introduced, a new head of surgery was hired with new staffing, space and equipment requirements, a change in the market for services occurred, new regulations were introduced, the paediatric facility was scheduled to be expanded, and so on. As a result of these continual changes, the facilities group found it impossible to get the addition they needed. To solve the problem, they decided to adopt an entirely new planning and management process, recommended by Mr. Urs Hettich, then architect and Director of the Canton Bern Building Department. The client's demand for long-term utility value in the addition to their facility defined the most important aspect of the new design and decision process: the ability to assure optimized adaptability in the face of changes in technical, social or political circumstances.

The traditional idea of delivering health care facilities up to now has been that it is easier and more economical to optimize a construction project by comprehending the "whole" with all its inter-dependencies. But in very complex buildings like hospitals, the hospital administration had learned that it is never possible to do so - that such facilities are too dynamic and can not be planned and built as if they are somehow "programmatically static". Rather, the "whole" will come into existence over time, in an incremental way. This means that large and complex buildings are never finished. In recognition of these realities, the project was split into three systems organized and conceived according to their expected life spans:

- Primary system (nearly 100 years)
- Secondary system and (nearly 20 years)
- Tertiary system (nearly 5 -10 years)

Figure 2.

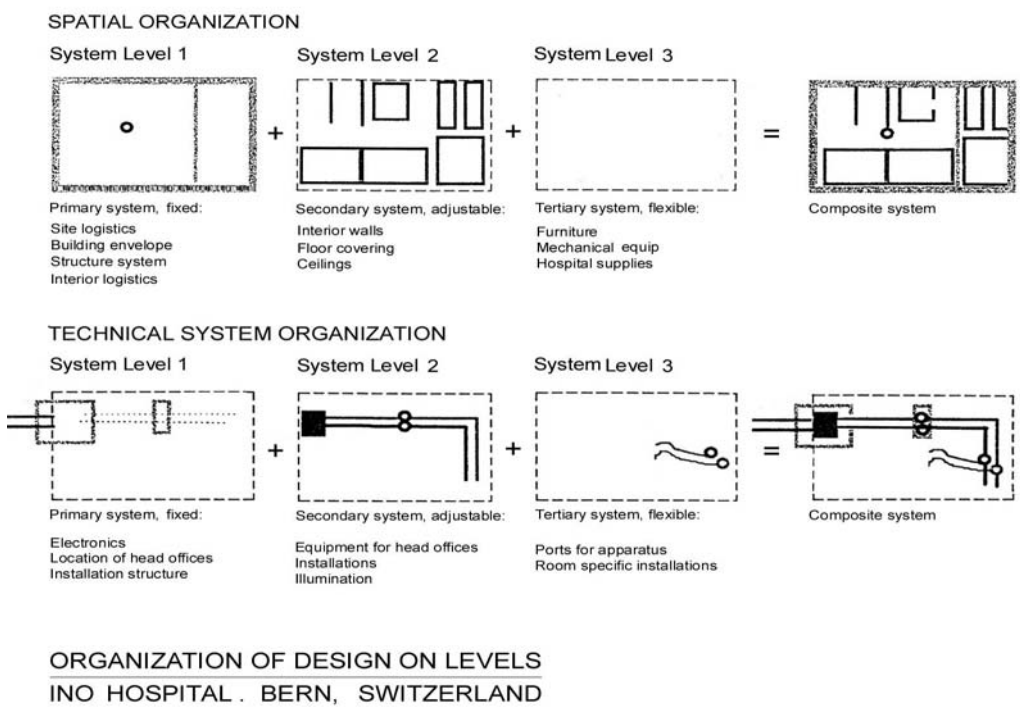


Figure 2 explains the basic approach to managing this complexity. The primary system determines the structure of the hospital and gives conditions for the development of the following systems. The interfaces are exactly defined, but the independence of lower level (secondary and tertiary) systems is as large as possible, in both technical and management terms.

THE JURY PROCESS

Primary System

After an international publication and call for entries in 1997, ten architecture teams were selected for the competition of the primary system. One of the criteria for this invitation was that the design team had never designed a major hospital project. The presentation requirements for the primary system were very open for the competitors except for the gross building area. A declaration of cost/capacity calculations and ecology/energy analysis were required. But layout scenarios were not required for the primary system. In addition, the competitors did not receive space-planning templates. Some projects proposed for the primary system were totally empty; some showed spatial arrangements of departments and spaces. It was up to the competitors to show the quality of their "open building". According to the project manager, it was not a problem for the jury to abstract and to compare. The Canton Bern building department used layout scenarios of the expected surgery theatres in the jury examination process.

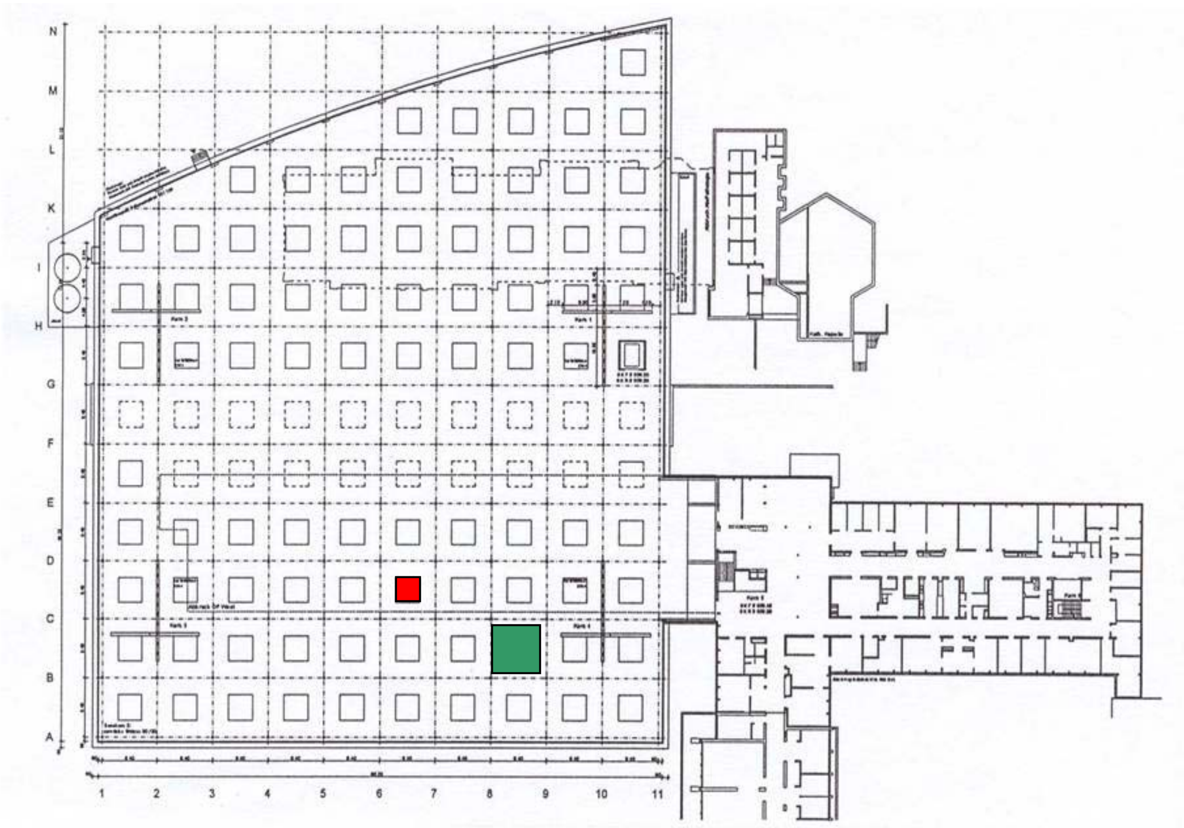


Figure 3: Plan of a typical floor of the Primary System, showing 8.4m x 8.4m structural grid. The primary System architect was Peter Kamm and Kundig, Architects. This firm

had designed one of the pioneering residential open building projects in Zug, Switzerland in 1973.

Fixed mechanical systems risers are placed in each quadrant. Fixed vertical and horizontal circulation routes are also located as part of the primary system. One of the planning innovations of the primary system shown in Figure 3 is the placement of 3.6m square “punch-through” opportunities (red square) in each structural bay (green square). Each of these (red) squares is a portion of the 20cm thick concrete slab without reinforcing. This offers the possibility of vertical penetrations at any location in the floor plate for vertical circulation, mechanical systems, or light shafts (see Figure 4)

Figure 4: Building Section showing one possible distribution of vertical light shafts. The actual shafts now in place are different from those initially proposed in the secondary system because the functional layout changed twice before secondary system installation even began.

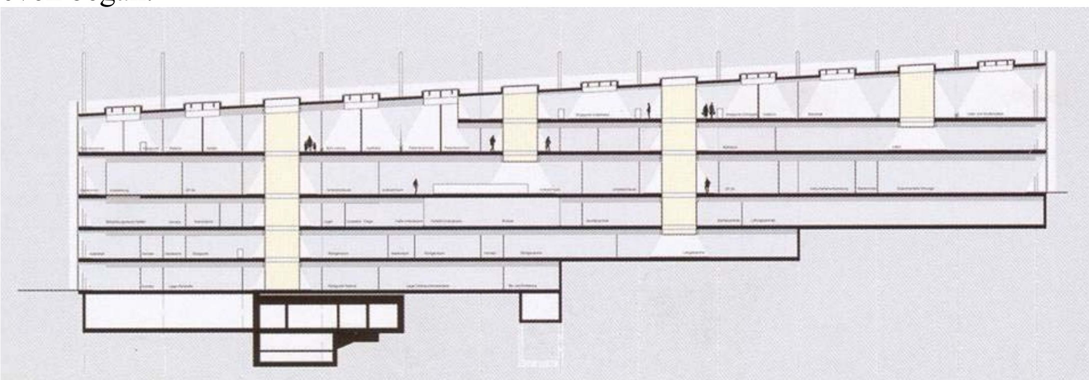


Figure 5

Figure 6

Figure 5. Roof of phase One of Primary skin with System – a ‘green’ roof with skylights.
Figure 6. West façade showing double operable windows behind a second layer.

Figure 7: Interior view of the top floor of the empty Primary System, showing skylights, openings for light-wells to the floor below (on right of picture) and pre-cast columns with four sleeves at the base of each column for vertical drainage piping – allowing highly

varied layouts. Also visible is the inner layer of the double skin envelope showing operable wooden windows.

Secondary System

For the secondary system the project managers demanded solutions for distribution of mechanical services and layout scenarios as well, showing typical patient paths. The competitors for the secondary system were required to be experts in hospital design. They each received a documentation of the primary system and the layout templates of the existing hospital. Submissions were required of firms submitting proposals for the secondary system to demonstrate - with drawings - how, for example, its proposed fit-out system could be deployed according to a range of programmatic scenarios within the given base building (already under construction).

Figure 8: One floor plan of the Secondary System, designed by Itten and Brechtbuehl, the winning team

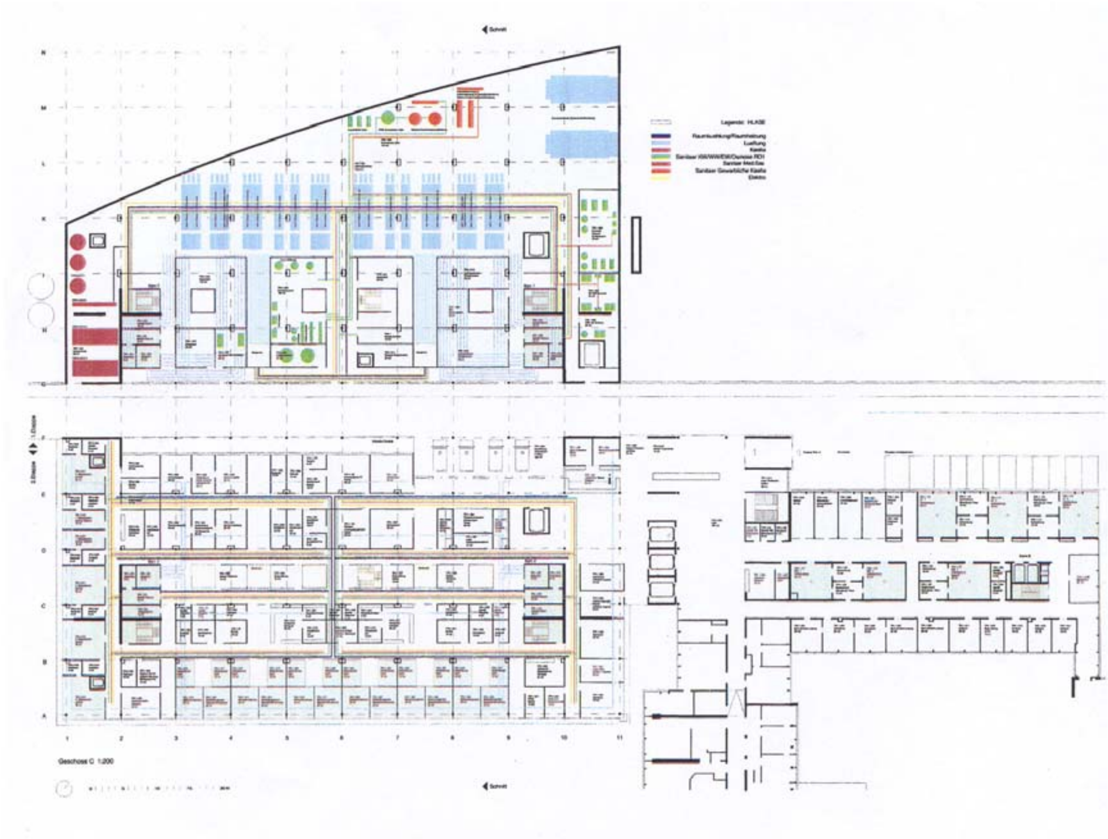
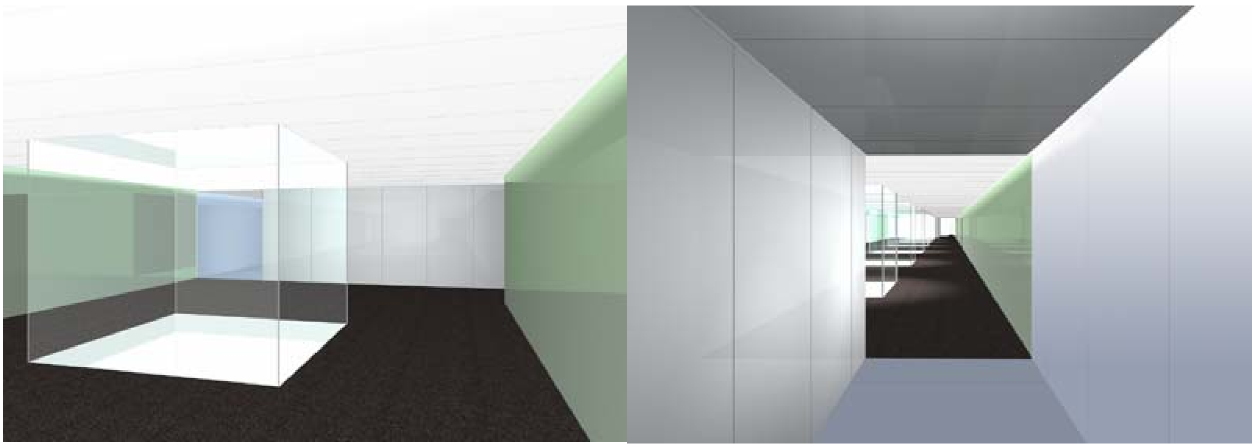


Figure 9: Interior perspectives of light-well lit corridors, part of the Secondary System design

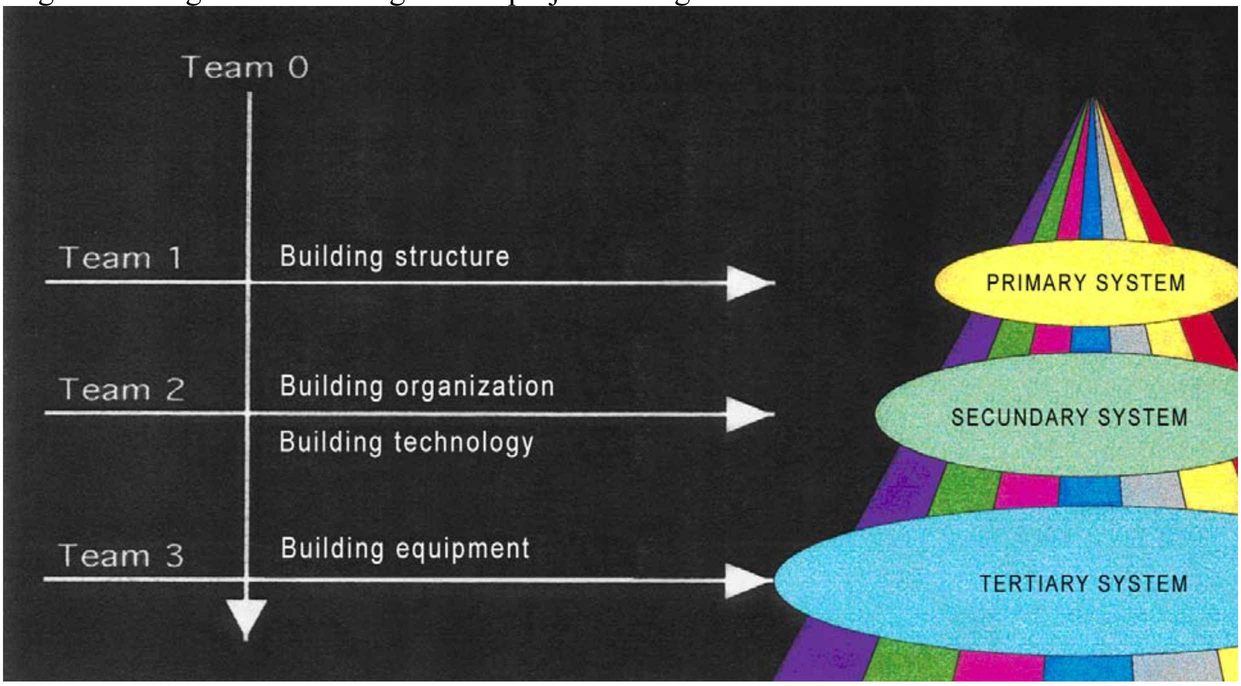


In both jury processes, competing proposals were expected to demonstrate a number of attributes: technical performance (building engineering, cost, ecology), serviceability (building structure/flexibility, function, construction timing, ecology) and architectural (formal properties).

This distributed management process – a radical departure from conventional procurement in hospitals but not in office buildings and shopping centres – was adopted to assure that the building would avoid the rigidity so often resulting from conventional procurement methods.

The Organization of the Process
The INO project is divided into three major system levels that consist of distinct and separate (but nevertheless coordinated) "management levels".

Figure 10: Organizational diagram for project management



In Figure 10, Team O is a firm providing the coordination of both the design and construction activities. The other teams each have their respective level of decision-making. As this report was being prepared, the installation of the secondary system was underway, with completion expected in early 2006.

PRINCIPLES OF WORK RESTRUCTURING AND DISTRIBUTED MANAGEMENT

The idea of dividing a large project into these packages differs from conventional project delivery methods used for medical facilities and presents challenges, not all of which were for-seen. It is worth noting that large shopping centres and office buildings are routinely managed in this way, but for some reason the principle has only now migrated into health care architecture in an explicit, structured way. An open building strategy organizes the project in terms of the anticipated duration of value of a cluster of subsystems. It does so to avoid waste, to optimize boundary conditions, to prepare the facility for long-term manageability in concert with anticipated changes, and to reduce costs of future adaptation.

These are also the principles advocated by lean construction (Lean Construction Institute), a production management based approach to project delivery representing a new way to design and build capital facilities. Lean production management has caused a revolution in manufacturing design, supply and assembly. Applied to construction, Lean changes the way work is done throughout the delivery process. Lean links the objectives of the production system–maximize value and minimize waste–to specific techniques and applies them in a new project delivery process. Lean Construction is particularly useful on complex, uncertain and quick projects. It challenges the belief that there must always be a trade-off between time, cost, and quality.

OPEN-ENDED MEDICAL ARCHITECTURE

This particular example of distributed design management is one way of organizing an "open building strategy" for the design, construction and long-term management of medical facilities. It is not necessary for different designers to be assigned to each level. But the "partitioning" of design management in this way is a strategy particularly well suited to institutional clients whose interests are long term, scrutinized by the public by means of state legislative action, and also must recognize competition from other similar institutions'. Inevitably, firms other than the original design teams are called upon to renovate medical facilities. In principle, then, this management strategy is not fundamentally different from the way large and complex medical facilities behave "in fact" (if not in the theories of "integrated whole buildings" now in currency).

The reason the Canton Bern decided to formulate and adopt this strategy is that it is aligned with the principle of variable life-cycle value of certain "clusters" of building elements and decisions. This is an accounting principle that corresponds to the behaviour of large complex facilities. That is, change and adjustment takes place on "levels" that cut across strictly technical systems and trade boundaries. For example, when a new illumination design is specified, it uses existing cable infrastructure "up to a point". When new partitioning is specified with an adjustment of offices, the design will seek to limit the perturbations of this change on contingent building parts, to save cost and disruption – i.e. the floor and ceilings will likely remain undisturbed, while some of the electrical cabling buried in the partitions will be changed but only "up to a point". Accumulated knowledge about medical facility behaviour under conditions of change should begin to teach us lessons about the boundaries of such "levels". They are likely to be cross-cutting, involving multiple trades and supply channels and therefore calling for new logistics and working methods.

CONCLUSIONS

As John Habraken (1998), Stewart Brand (1994) and others help us to see, the built environment is not static. Transformation is pervasive, operating at various time scales and at various "levels". We would be surprised if things were otherwise, and not only that, we would be out of work. It is, after all, the work of architects and other designers to help manage what should be built. But to a large extent our working methods are not yet congruent with this reality. We are only slowly recognizing transformation and stability as twin realities. Our teaching, our design and construction practices and our analytical and accounting tools are not yet sufficiently organized in recognition of this. Product manufacturing is much more advanced. Lean construction recognizes this reality, as does some pioneering engineering research.

The commitment of the Canton Bern Building Department and the INO Hospital to the open building implementation should be applauded and scrutinized. At the time of this paper's preparation, the Canton Bern Building Department Administration is developing guidelines for the procurement of all future projects based on the lessons learned in the INO project. The guidelines explicitly define "levels" and "interface rules" and performance based on distributed design management in the service of flexible architecture. This decision, according to interviews with the staff, flows from the efficacy already exhibited in the separation of the three levels. Their autonomy (the word used by the Director of the Building Department) must be maintained as a matter of principle. Changes made in the functional program since planning began 7 years ago already demonstrates the effectiveness of the strategy.

Acknowledgements
Stefan Geiser, Architects, Manager of the INO Design Coordination Team at the Canton Bern Building Department, has been instrumental in helping us study this project, supported by the Director of the Canton Bern Building Department, Giorgio Macchi. Our research team has included the following individuals: Douglas Reddington, BSA LifeStructures; Dr. Thomas Bock, TU Munich; Dr. Quinsan Ciao, formerly at Ball State University Department of Architecture; Dorothy Dettbarn, former Graduate Student, Department of Architecture, Ball State University. Financial support for this research and documentation has been provided by the American Institute of Architects Foundation, BSA LifeStructures, Architects and Planners, Gaylor Group, and Meier-Najem Contractors.

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3D - A TOOL FOR INSTANT PARTICIPATION AND COLLABORATIVE URBAN DESIGN

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Abstract
Based on experience gained from an urban renewal project in Noerrebro, Copenhagen, the potential power of visual ICT tools is discussed. In Copenhagen experiences were gained by using different ICT solutions, including the use of web-based information about the project, photo-safaris of best and worst places in an urban area conducted by school-children, accessibility in the area from the view of a wheel-chair user, 3D visualisations of design of buildings and streets - and a 3D immersive virtual model of the Noerrebro Park, where visitors could get information about the renewal projects, as well as debate in real time on a bulletin board. At least in the Copenhagen project especially 3D modelling had capabilities to involve new types of stakeholders in the area, to establish consensus about solutions and to generate a common understanding and shared knowledge of the shapes and functions of the urban solutions for different stakeholders.

Keywords: Collaborative participation, ICT, 3D, urban renewal

BACKGROUND

The experiences for this article stem from a project on Urban Regeneration on Noerrebro, Copenhagen, The Noerrebropark Kvarterloeft[1]. In cooperation with the renewal project a researcher team from Danish Building Research Institute and Royal Danish Academy of Architecture developed and analysed ways to use the Internet to strengthen the public participation in the process of urban renewal. Further information about the research project, The Electronic Quarter, can be found at www.e-kvarter.dk and in two research reports (Holmgreen, Rüdiger, Storgaard and Tournay, 2005) and (Storgaard and Madsen, 2005)[2]. In Danish urban renewal projects supported by the State public participation is statutory, but it can be conducted in a lot of ways with very different consequences for participation – as well as physical and social outcome.

Like in many western democracies Denmark has a long tradition of public participation in urban planning and in urban renewal projects. A tradition far longer than the process that in the 1990s was designated as governance and was to be observed in most western societies (Rhodes, 1997). *Governance* designates the process where government carried out by experts and politicians is replaced by a *process of management*, where users are involved, not only at an informational level but also as participants in the process of

1 Kvarterloeft Noerrebro Park is running 2000 to 2007. Website: www.parkkvarter.dk

2 The project, The Electronic Neighbourhood (or The E-Quarter for short) was financed by the Ministry of Housing and the Ministry of Social Affairs. Also The Ministry of Refugee, Immigration and Integration Affairs, The Municipalicy of Copenhagen and the MODINET project have contributed. The project is conducted by Danish Building Research Institute, SBi (architect Steen Holmgren og sociologist Kresten Storgaard) and the Royal Danish Academy of Architecture (architect Bruno Tournay (3D modelling) and architect Bjarne Rüdiger (web visualisation)).

making visions and plans. *Networking* – or *cultural management* are also words used to characterise this type of policy management. The English urban scholar, Patsy Healey, characterises the process as *collaborative planning* (Healey, 1996).

A DEMOCRATIC ISSUE

Most analyses surrounding the process of governance have focused on democratic issues. A new type of democratic problem occurs in this deliberate form of democracy that characterises this user-based type of policy management: The most active stakeholders have more influence than the less active ones. And individual resources and competencies needed in order to be active and to participate are to a large extent a question of social structure. Therefore the ability to participate is not only a personal question. Especially in Denmark this democratic problem has been the focus of several studies (Sørensen and Torfing, 2000; Engberg, 2003). But instead of looking solely at democratic issues, one might have a glance at the collaborative process itself, which was what Patsy Healey drew attention to.

THE PROCESS OF COLLABORATION

Collaboration means cooperation between different actors – with emphasis on the word different. In her study of several English planning projects, Healey observed that stakeholders actually come to agree despite all their differences. In Patsy Healey's optic this agreement is the result of a communication process, in the working groups - a communication process very close to Habermas' concept of the communicative rationality in his theory of Communicative Action (Habermas, 1981). For Habermas, the ideal was domination-free communication where agreements have their own logic of conviction. In practise a lot of problems are often seen to occur. Power structure is one of them. Nevertheless Patsy Healye – and later Judith Innes — sticks to the communication process as the core process , where agreement emerges. Judith Innes in particular has focused on what makes people agree. First she identifies what she designates as an authentic dialogue. She observed that in the working groups agreements are not achieved through ordinary trade-off logic (Innes & Booher, 2003, p. 43). Nor is consensus obtained through rational deductive argumentation (as a Habermasian type of rational communication process would indicate). It was achieved through what she designated collective story telling – about interests, about problems, consequences and visions. Mutual relationships develop through this process of collective story-telling and dialogue that builds up social and cultural capital among the different stakeholders and establishes new relationships. Innes designates these relationships as *network power*. And network power is the glue for collaboration over time, she says (Innes, 2004, p 13).

Despite the focus on communication to gain agreed solutions in urban projects and to gain cultural and social capital as a communicative spin-off (Storgaard and Holmgreen, 2005), neither Healye nor Innes pays special attention to the possibilities that ICT may offer. Can this technology be developed so that it can strengthen the collaborative potentials that seem to be connected with participation in project and working groups in urban planning and renewal. In the next section we will pay special attention to this topic, following the experiences from the project The Electronic Neighbourhood, a project with the specific aim of analysing and developing ICT tools to strengthen the scope for public participation in urban renewal. Research and development in the same project is an approach designated as *dialogue research* (Storgaard, 1998).

EXPERIENCES FROM NOERREBRO, COPENHAGEN

In the e-quarter it was the hypothesis that the new ICT could be developed proactively to strengthen the process of public participation – not in the least the process of collaboration.

The home page – a tool for instant participation

The web has been become essential in all urban renewal projects. In the Urban Renewal Project the home page was an active tool for communicating information from the secretariat as well as from the working groups. Information could be found on the home page and minutes from working groups and information from the secretariat were central. Fancy and animations were not seen. In this way the home page functioned as a file, where everybody could find information about what was going on – such as suggestions, proposals and decisions. Also there was a place for debate, but only few used this facility. Over a 2-year period only a total of 18 persons took part in the debate. And the three most active persons counted for 65 % of the contributions. Only rarely did a debate take place. Mostly it was only one-way communication presenting one's own viewpoints. The stakeholders in the area were not the only ones to visit the home page. Other visitors were administrators at the municipality and the parties involved in the urban renewal tasks, as well as researchers and other renewal projects in Denmark and abroad.

In the research project, the Electronic Neighbourhood, the home page was also where information about the project and its applications was developed (described below) were presented. But the traffic was not very high. When most people visited the home page over a 14-day period in August 2003 as part of a Cultural Marketplace initiated by the Urban Renewal Project, the daily average of visitors was 46 persons.

It was the conclusion that a home page can be organised to be the place where citizens can easily get information about the work taking place in the working groups and in the secretariat, without necessarily having to be present and participate in all activities. Organised the right way it opens up for *instant participation* – newcomers can participate very competently in working groups because they have good access to information, discussions and the history of the group. Instant participation corresponds well with the lifestyles of society of today. Many people do not want to participate in the traditional full-time way. But they are very keen on what goes on just at their doorstep. Accordingly to this not all “traditional” participants are happy about newcomers' “easy” way of participating.

Visualisation in 2D: Photo-safari

In the e-quarter project visualisation was planned to be an important tool for communicating visions as well as the hidden or tacit knowledge about the area the citizens were bearers of. Pupils in two classes in each of the two schools in the local area were given disposable cameras and were sent into the street to photograph the best and the worst places in the area, and to add a few comments. The results were introduced to the community at an exhibition and on the Internet the results were presented on the home page of the research project. Linked to a GIS map, pictures and comments were presented. Also a wheel-chair user used the photo-safari to inform about accessibility in the area. To the takes showing accessibility problems in his neighbourhood, a few comments explained the problems and provided some solutions. In the same manner this was presented on the net.

The user-interview afterwards showed that visualisation – even in the simple form of a photo - is an adequate tool for communicating tacit knowledge of groups/stakeholders normally not used to participate in public participating projects. The effect of the school children's photos was primarily seen in the school itself, where it positively influenced the work in the classroom and contributed to the integration of pupils and school in the urban local context. The result about accessibility was not to be seen in the debate taking place in the renewal project – which was what the researcher thought would happen. But nevertheless it had a significant effect. The wheel-chair user contacted politicians and let them visit the pages. And so did the handicap organisations. It was an important tool and input to the development of a specific policy about accessibility in the area.

The simple visualisation techniques proved to be eminently good for communicating tacit knowledge – and for involving stakeholders who are not often seen participating in renewal projects.

Visualisation in 3D

A 3D model was built up for the whole renewal area and for two selected areas detailed models were made. In two proposals about renewal of streets suggested by the tenants, a 3D model of the specific areas was used to strengthen the work with the proposal. In one case it was the street of Asminderoedgade, where a group of tenants had actively worked out suggestions. In the other case it was the activists in the Youth House who wished to improve the appearance of a "dark and ugly" passage next to their house.

Asminderoedgade

Based on suggestions made by the tenant, the ideas were visualised by means of a simple photomontage, on plans and drawings, but especially via a 3D model of the street. On a video tour through the street the visitor could get an impression of the suggestions. Interviews afterward showed that the tenants saw visualisation as a strong way to develop and communicate their wishes, among the tenants and to the renewal organisation. In the further work with the plans, an architect used 3D to illustrate part of the further suggestions. As a matter of fact, they wanted ICT facilities to strengthen the communication between all the tenants.

The Youth House

The Youth House is the locality where young activists from the Copenhagen area meet to plan actions, to organise concerts, workshops, etc. It is also the place that scored the highest marks in the school children's photo-safari as the ugliest place in the neighbourhood. To show their interest in their neighbourhood, the activists had suggested the embellishment of an alley next to their house. In collaboration with the 3D architect of the e-quarter project, a 3D virtual vision of the suggested embellishment was modelled, enabling ordinary photomontage visualisation as well as a guided video tour.

Afterwards the interview showed that the activists saw the perspective of using 3D. Despite the fact that the project was not realised, it was the opinion that the 3D visualisation was an effective way to communicate their proposal to the surroundings, without any disturbances caused by the identity ascribed to the sender. And it was a tool, which invited to collaboration, potentially even with developers. Evidently there is a potential for inclusion – getting culturally and socially different stakeholders to interact positively with a focus on at future solutions.

3D - an immersive virtual world

As a last project the 3D was used to build a parallel virtual world of the green park of Norrebro. In this central area of the renewal zone, the renewal organisation in collaboration with the voluntary associations in the area holds a Cultural Market Place during a week-end in the summer. The voluntary associations are represented in a booth each and the renewal organisation was represented in several booths, tents and containers as well. In a container the e-project rigged up several PCs, where the visitors could visit a virtual 3D model of the Noerrebro Park. Visiting the park as a shown avatar, visitors could walk about, visiting different booths and reading their information sheets. At two of the booths, they could even be "teleported" to two other virtual worlds. In one a renewal consultant could tell them in a power-point presentation about the renewal of shops. And in another virtual world the visitors could walk about in a downscaled 3D model of the park and its surroundings, or inspect a photo exhibition of historical photos of the park. The visitors could also chat in a chat box. On an occasion two weeks later, new visitors were asked to visit the virtual park and investigate further this feature in particular. Subsequent interviews with the users showed a significant interest in using the media as part of the process of participating in the renewal process. And the experiences with the chat box gave a hint that it might be developed to function as a tool for lively communication among stakeholders. The similarities with the short communication form of the SMS are evident. In the renewal organisation a person suggested that the chat box should be manned half an hour a week. But it was never realised.

ANALYSING THE RESULTS

Actually the professional planners of the renewal organisation were far more sceptical regarding the 3D media than the ordinary users. The professionals did not find that it contributed much to uncover new material. As they saw it, most could already be found in their maps and material. But the other stakeholders of the area saw great opportunities by using the new media. It was much more interesting and informative to see suggestions raised in the spatial digital world. The research team concluded (Holmgren, Rüdiger, Storgaard & Tournay, 2005) (Storgaard & Madsen, 2005) that the 3D medium had the potential to be developed into a tool for:

- Instant participation
- Inclusion
- Sharing of knowledge and learning
- Sharing of visions

And it was observed that while text-based media – especially the text-based debate forum – was a media which centred attention on differences – on what makes a difference – the visually focused media had a tendency to bring attention to what solutions could be agreed.

Take note of the above phrase: “has potential to be developed”. Technology does not develop by itself, but is a complex social construction with structures of affordables to be developed (Jæger, B. (1997), Hoff and Storgaard (2005)).
And the use of 3D is to be developed. Professionals in modelling, communication and mediating functions will be central persons. The function of the planner will to a higher degree be changed to that of a mediator and 'translator' who involve and 'reformulate' wishes and suggestions of stakeholders into a language that 3D can accept. It could be a problem that the professional planners do not see an urgent need for developing 3D. They have already the competencies to read and formulate the visions in a plan. The civic stakeholders on the other hand do have the needs – but not the competencies.
Below we shall focus especially on the process of knowledge sharing and visions and collaboration.

COLLABORATION AND KNOWLEDGE SHARING

In the e-quarter project it was the experience that the meeting between stakeholders could work in two ways. The debate could be what Innes, following in Patsy Healey's footsteps, called an authentic dialogue, i.e. that stakeholders experienced that other stakeholders have a right to their own wishes and their use of an area. And that they accepted these different uses and wishes to the city through the process of participation.
But the experiences from Danish renewal and participation projects also show that the debate could follow another track. The meeting could easily be where the debate turned into a struggle between what would then become incompatible proposals representing different interests. Solutions should then be taken, not by a common agreement – or consensus, but in a “full” democratic way – through voting. Or by a higher instance: the renewal secretariat. Such observations are in accordance with experiences from many cases in the urban renewal projects that SBi has analysed. In a case of renewal on Vesterbro in Copenhagen, one met the sentence – that workgroups could function – until “democracy” entered the debate. By this sentence was meant that sometimes people began to discuss not the case, but the principles behind it, the general “hidden” political issues. And at that point one might argue that it was a debate among and between character-masks, which had taken over. Typical tenants (seen as 'Labour Force' and 'Left Wing') on one side of the table – and business people on the other (seen as the 'Capital' and 'Right Wing'), despite the fact that in the concrete matters the interests were very mixed – and followed no simple pattern.

In the e-quarter project, we got a hint about the use of 3D modelling and that the heavy use of visualisation has a potential to increase the collaborative process between different stakeholders, of getting a mutual understanding and acceptance of other persons' use and wishes to the area and to increase the process of inclusion. So it seems that the use of visualisation as a tool of dialogue might have a potential for the facilitating the collaborative process. While text, debate form and spoken words alone might seems to facilitate focus on differences, visualisation and 3D seems to have a potential for facilitating the collaborative process of public participation.

The potential of visualisations might be that it also makes one focus on agreeable features and not only on difference. At a glance one focuses on exactly what concerns one's own affairs – and one cares only about the other solutions, when it makes an apparent difference to what you are going to do. Communication carried out by words and text easily focuses on differences. The logic of debate is to focus on the differences – on what makes a difference. And one might argue that one difference easily brings a new one to light – and the debate can continue.

TRANSFER OF KNOWLEDGE AND 3D VISUALISATION

In the process of the collaboration that takes place in the working group it is the argument of Innes that in the process of authentic dialogue, one begins to understand one another – the other's use of the city – and therefore to understand the other's wishes to future solutions. This could be designated as a process, where a transfer of knowledge takes place. This shared knowledge is the base for developing shared visions. Or visions, where the stakeholders of the area can see themselves to be included without necessarily to have reached agreements on every part. By relating this process of knowledge sharing to the process of participation and dialogue, a new way is introduced to seeing and understanding the process of collaborative design that takes place in the urban renewal project – and in other collaborative design projects as well. Knowledge sharing is not so much a question of arguments – as stated in a Habermasian approach. It is our argument that this transfer of knowledge goes beyond the explicit formulations of mind and speech. A lot of tacit knowledge is transferred as well.

Nonaka and Takeuchi (Nonaka and Takeuchi, 1995) have focused on the processes of transferring different types of knowledge. Polanyi (Polanyi, 1966/2000) introduced the distinction between formal knowledge and tacit knowledge. Nonaka and Takeuchi have brought the discussion a big step further. They focus on the transfer of the different conversions of knowledge.

Fig.1. Modes of creation of knowledge

From: / **To**:	Tacit	Explicit
Tacit	Socialisation	Externalisering
Explicit	Internalisering	Combination

Source: Nonaka and Takeuchi (1995)

Fig.2. Creation of knowledge and visualisation

From / **To**	Taci	Explici
Taci	Socialisati Imagification/ Visualisation	Externaliseri Illustration
Explicit	Internaliseri Medialisation	Combinati Factual Propagation

In traditional western-based teaching and learning activities, one traditionally thinks only of the transfer of explicit knowledge as what matters. And in planning, most professionals think the same way concerning debates and working groups. Data are exchanged against data. But in the optic of Nonaka and Takeuchi this is only one transfer out of four (Nonaka and Takeuchi, 1995, p 62). They designate this process of transfer of knowledge as *combination*. The transfer from explicit to tacit knowledge they designate as *internalisation*. One learns the explicit to such an extent that it becomes a part of one. The transfer from tacit to tacit they identify as *socialisation*. And the process from tacit to explicit, they designate as *externalisation*.

Nonaka and Takeuchi see the transfer and creation of knowledge as a spiralling process: Starting in the socialisation mode, a process of field building is started. In the externalisation phase dialogue or collective reflection takes over, followed by networking where formal experiences are linked to each other in the combination mode. And finally the explicit experiences are internalised in the actors (the SECI model).
One may be critical of this more or less implicit phasing of the transfer and one could argue that all modes are part of the transfer – all the time: but in varying degrees.

In our optic the four modes of knowledge conversion can be used to understand why especially the new ICT media and in particular the visually based communication has the potentials mentioned above. Looking at the four modes of knowledge creation, it becomes evident that ICT has potential to boost the transfer. And it is evident that especially the capacity to use visualisation as one of the tools is very effective. Transferring explicit knowledge by means of explicit speech and text is often central in any process of knowledge transfer, but visualisation by figures, graphics, 3D models as well as pictures are all helping agents. Difficult microbiological processes become understandable even for non-scientist through 3D architecture that shows simplified models of gene structures.

The transition from the field explicit to tacit knowledge, the process of medialisation is a significant characteristic of the everyday life of today where everything is experienced through the media. A process that influences the whole society in a very opaque way. In Denmark this process is in focus with high priority by the Danish Research Councils, through the MODINET project (Modinet, 2002) (Hoff & Storgaard, 2005). Especially the TV media is seen to affect society strongly. Also some types of advertising can be classified in this field. Having a specific message to be part of the user habits.
In the field of tacit to tacit and from tacit to explicit we have to do with communication 'between the lines'. A lot of communications from artisans are to be found in those fields through music, painting, sculpturing, movies etc. Visualisation is important. A lot of tacit feelings, sentiments and moods, but also messages that are sent so as to become received explicit messages. Visualisation is decisive for the communication and establishment of shared visions in the urban landscape (Sukin, 1995).

PERSPECTIVES

In this light it is not so surprising that virtual 3D and other ICT carried visualisations might have a potential to transfer knowledge, whether explicit or tacit. And it is not surprising that especially the 3D modelling might be developed to be a strong tool in collaborative planning. One may add: And in other collaborative processes as well, not in the least in the building sector. Research and development especially for the building sector is carried out at the SBi by the modelling work of Nils Lykke Sørensen (Lykke Sørensen, 2003, 2004). 3D models are not only to be seen as an extra dimension added to a CAD drawing. It is quite a new tool – for collaboration, as stated in this articles, or a tool for rough reckoning and calculation of prices, energy, materials etc. as well as a tool (or user interface) for gathering information of drawings, construction details, information about material etc. In this light 3D modelling as an exact copy of a building, which is the overwhelming viewpoint in today's building industry, is only one way to use 3D. A 3D "look-a-like" could successfully function as an effective tool – for collaboration, for calculation and as a frame upon which more specific information could be drawn. To this purpose the 3D machines in the game industry are of great interest. What is needed for those purposes is not high exactitude but fast mobile transfer.

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FUZZY DESIGN MODELLING

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Abstract
One of the fundamental problems with current forms of digital design information is its crispness. Especially in the early design stages the apparent precision requirements for input may impede creative thinking and effective communication. In later stages the crispness of computer models may remain a problem e.g. in terms of adaptability, flexibility and feedback. The paper proposes that fuzziness can be added to design forms and decisions in order to express tolerances, uncertainty or delegate secondary problems to later stages. The result is a digital modelling environment that has the same feeling as analogue sketching and diagramming but with the added advantages of computing power for e.g. efficient storage, plasticity, automated recognition and constraint propagation.

Keywords: fuzziness, local intelligence, representation, sketching.

INTRODUCTION

Design information processing with the computer is becoming increasingly ambitious. Computer-aided modelling is arguably the first technology to support accurate and precise description of built form (Evans, 1995). Complex geometric constructions and even free forms can be drawn and manipulated not only unambiguously but also with relative ease. Information standardization is available in the form of building information models, classifications of design entities and exchange systems such as the Industry Foundation Classes (IFC). These support not only communication between different disciplines but also integration of aspects and continuity of design information throughout the design process. Integration and continuity add to the complexity of the specification of built form and invite the application of advanced techniques such as parametrization to add constraints that control the appearance, structure or behaviour of a form.

The results of such developments are high expectations from design representations and information processing. However, such expectations are accompanied by equally high requirements on the user. The development of an advanced, complex information system for a particular design project is a time-consuming and labour-intensive task that also involves many parties. Maintaining the information system is even more intensive, sensitive to user or system errors and critical for the success of the project (Gauchel et al., 1992, Hovestadt and Hovestadt, 1999). Moreover, while the computational techniques in such systems may be advanced and reliable, the underlying theories and methods tend to be sketchy and motivated more by technology transfer than analyses of domain problems.

The limitations of the theoretical and methodical framework become evident especially in extensions of the core applications. For example, information models and design entity classifications should also support continuity in the design process, i.e. transition between design stages. This implies the ability to describe an entity at multiple levels of abstraction. However, the presence of entities itself may be a problem. In the earliest design stages, for example the entrance to a space is generally only implicit as a relationship of adjacency between two blobs indicating spaces in a floor plan sketch (Figure 2). In later stages this relationship may lead to the insertion of a door in the design, initially as an abstract symbol merely indicating the general type of the opening. As the design process evolves, the door is specified with more precision but not always in a predictable or orderly fashion. Issues such as fire safety do not apply to all doors but only to an arbitrary subset, which receives additional constraints with respect to materials and dimensioning (as a result of critical factors in the pedestrian flows that pass the door).

Similar problems undermine the use of external properties and constraints, even in seemingly straightforward cases such as the parametrization of stairs. Practically every self-respecting CAD system offers facilities for the automated design of stairs. However, the basis of most of these facilities, Blondel's formula and its variations (usually expressed as: 2 x riser + tread = step length or approximately 65 cm), is long known to be erroneous (Templer, 1992). Still, the formula remains dominant in stair design and analysis, including most building regulations in the world. What makes matters even more complex is that stairs combine geometric with topological parametrization. The geometric part refers to the form of a tread (on the basis of e.g. Blondel's formula) and the topological part to the structure of the stair as a whole, i.e. the number and arrangement of treads (Mitossi and Koutamanis, 1996). In parametric stair design it is not always clear what the extent of each part is, i.e. when a system stops tweaking the sizes of the treads and changes their number and the overall fall of the stair.

Such limitations illustrate the two main problems of current approaches to design information representation and processing: (1) the weakness of computational domain theories that guide computerization, (2) the high complexity and specificity of information systems and the resulting burdens of development and maintenance. Two issues that link the two problems together are:
1. *The limited use of local autonomy and intelligence:* representations of design entities can operate semi-independently and take decisions without user interaction if placed in frameworks comprising a relatively small number of constraints. This means that e.g. a door may change its swing direction or dimensions in order to meet egress requirements, providing these changes do not affect a harder entity in the immediate area, e.g. a load-bearing element.
2. *The crispness of representations and constraints:* a frequent complaint is that computerization forces designers to register their decisions and actions in forms that are too precise and afford little plasticity. This becomes evident if we compare analogue with digital representations, e.g. a floor plan sketch or a volumetric working model with a CAD drawing or photorealistic rendering. Analogue information has a vagueness that seems appropriate for early design and adds tolerances to later stages, while the same digital information is generally too crisp for the design thinking from which it emerged.

FUZZINESS IN ARCHITECTURAL DESIGN

The aim of the research reported in the present paper is to develop means for expressing the plasticity and adaptability of design entities during the design process in a way that allows for automated processing of local information. The key concept of the research is that of fuzziness. Fuzziness is not uncommon in design thinking, nor in analogue design representations. For example, probably the most frequent type of information in floor plan sketches is *organizational lines*, indicating a framework of drawing that may extend beyond the outside limits of objects and may cut through objects. Spaces are frequently explicitly represented in floor plan sketches, as closed contours or bubbles. The limits of different spaces may not be sharply demarcated. Both organizational lines and space bubbles are usually drawn with *multiple lines,* by far the most popular in floor plan sketches. These make the outline of an entity vague and indefinitely stated. This agrees with the reluctance to make hard commitments in early stages, as well as with the informality and metric flexibility of sketching (Koutamanis, 1999).

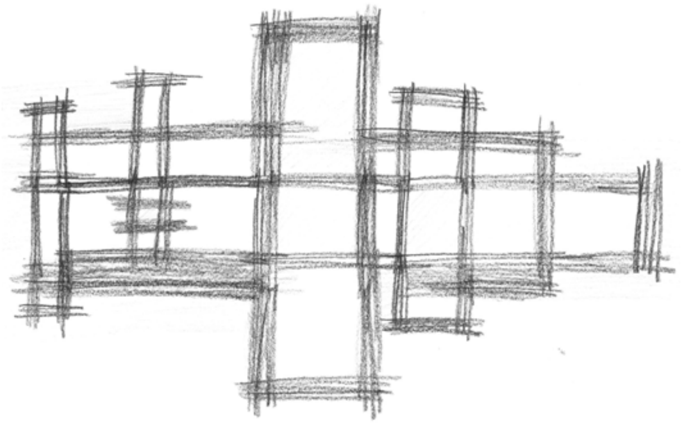

Figure 1. Organizational lines drawn with multiple lines

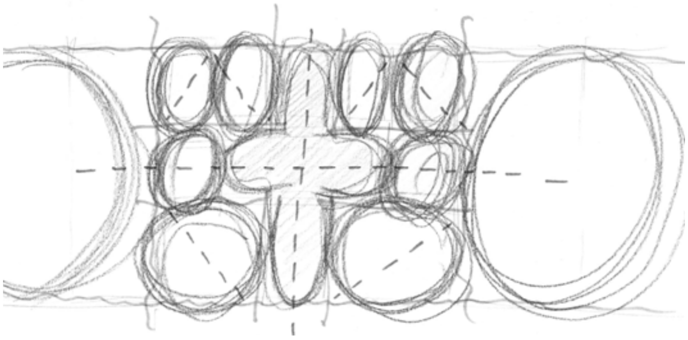

Figure 2. Space bubbles drawn with multiple lines

Fuzziness in floor plan sketching expresses tolerances in size, form and place that agree with the abstraction of early design. As the process proceeds, the specificity of the design increases and values become precise. However, this does not mean that tolerances disappear. On the contrary, some tolerances may increase. As partial solutions become fixed, decisions on some of their aspects may go beyond previously established limits. For example, a space that does not fit in the floor plan may be translated to an extent that alters the overall form or the topology of the design. In a similar manner the plasticity of design entities grows as the specificity of others increases. An infill wall is frequently and extensively adapted in response to changes in e.g. intersecting load-bearing elements. The same happens with the integration of service components, the positioning of doors and windows or any other spatial relationship with more critical or sensitive entities.

Such examples illustrate how extensive yet vaguely defined design tolerances can be, as well as how extensive their influence can be on plasticity, flexibility and adaptability. Expressing such tolerances as parametric relationships requires extensive constraint propagation networks that must be continuously updated with respect to changing priorities and conditions. An alternative is to use essentially the same cognitive and representation devices as in the above examples and fuzzify design representations.

FUZZY FORMS

Fuzzification of a design representation relies on the transformation of the crisp values of design entities into fuzzy numbers. These are described (in their simplest form) by triangles. In these triangles the apex is set above the crisp value *C* and the base indicates the tolerances (range of fuzziness) for this value. The base has a left-hand limit *L* and a right-hand limit *R*. The number is therefore described as (*L, C, R*), e.g. (3, 5, 8). The values in the range have various degrees of membership, ranging (for a triangular fuzzy set) from 1 at the apex to near 0 at the left and right-hand limits.

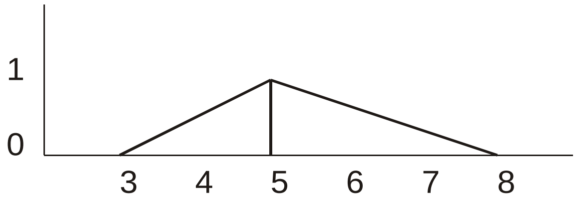

Figure 3. Triangular representation of the fuzzy number (3, 5, 8)

Fuzzy shapes can be implemented in three alternative forms: as canonical objects with tolerances, as forms described by minimal and maximal values, and as point sets.

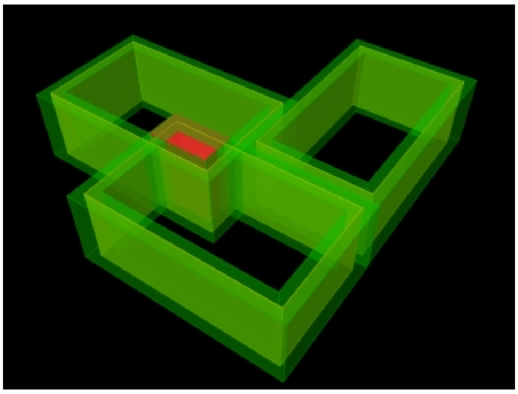
Figure 4. Canonical spaces with tolerances

In analogue sketching the designer describes the form of a primitive in a *canonical form*. The media used for the description indicate the geometric and spatial tolerances for the primitive. For example, thick or multiple lines may indicate uncertainty and flexibility in the position or shape of a space boundary. In fuzzy modelling the canonical form is explicitly described, together with tolerances that express the variation in the position of the canonical form. This is one of the simplest possible forms of fuzzy geometry (Buckley and Eslami, 1997a, Buckley and Eslami, 1997b) and relates to proposals on the fuzzification of solids and parametrization (Yamaguchi et al., 1992, Pham, 2002, Pham and Zhang, 2000). In lines tolerances are described by a left-hand offset *L*, the canonical shape *C* and a right-hand offset *R:* (*L, C, R*). In contours the fuzzy shape *F* is described by an inner limit *I,* the canonical shape *C* and an outer limit *O: F* =(*I, C, O).*

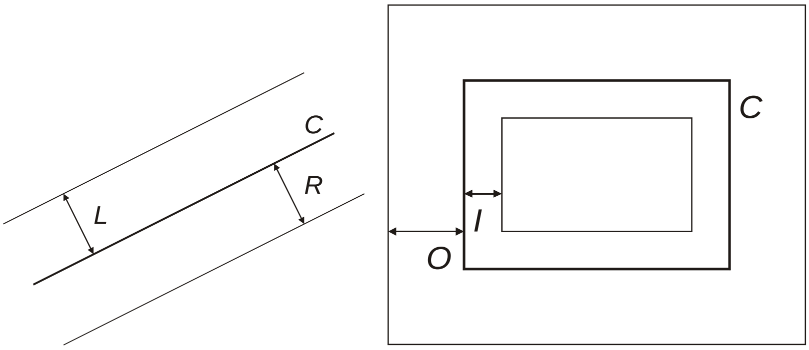

Figure 5. Fuzzy line and fuzzy rectangle

The coordinates of a fuzzy shape are described by fuzzy numbers. A canonical shape *C* with the coordinates ($x_0\ y_0\ x_1\ y_1\ \ldots\ x_n\ y_n$) becomes fuzzified into the fuzzy shape *F:*
$F = (I, C, O) = ((I, x_0, R)\ (I, y_0, R)\ (I, x_1, R)\ (I, y_1, R)\ \ldots\ (I, x_n, R)\ (I, y_n, R))$
This suggests that tolerances can be attached either to the shape or to its salient features, primarily its vertices.

If we dispense with the canonical form, the tolerances define an entity by its *minimal and maximal values*, i.e. its potential extent as a range of acceptable positions and sizes. The definition of a fuzzy shape *F* becomes $F = (I, O)$. The inner and outer limits are no longer constraints on a canonical shape, but the minimal and maximal version of the shape. Such a definition implies a greater degree of flexibility or uncertainty, as it diminishes the number of salient features in the shape. Entities defined by a canonical form with tolerances can coexist with entities defined by their minimal and maximal values. Such coexistence may suggest a differentiation of entities in terms of specificity or hardness, with beneficial effects for the resolution of local problems by means of variable plasticity.

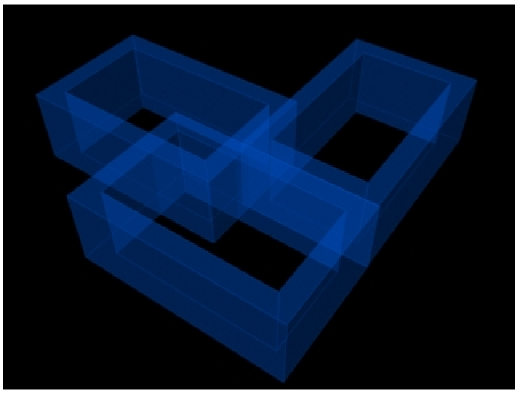
Figure 6. Spaces described by minimal and maximal values

One step further from minimal and maximal values is the complete fuzzification and discretization of a form and its representation by a *point set of particles* which define a fuzzy boundary for each entity. The behavior of a particle is semi-autonomous, on the basis of its affinity with other particles of the same boundary (density and hardness of the boundary expressed in spatial or structural relationships between particles) and its spatial relationships to particles of adjacent boundaries (proximity and composition of neighborhood). Such relationships form the basis for the transformation of the particle model into a continuous geometric model (Horváth et al., 1999, Rusák, 2003).

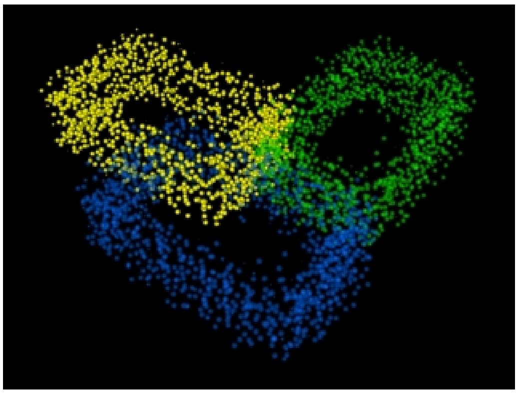

Figure 7. Spaces as point sets

FUZZY OPERATIONS

Fuzzy modelling facilitates the autonomy of entities and the consequent automated resolution of local problems. The first stage of local intelligence and autonomy concerns the *self-regulatory adaptation* of a form. In its simplest form adaptation becomes uniform scaling of the canonical form within the defined tolerances.

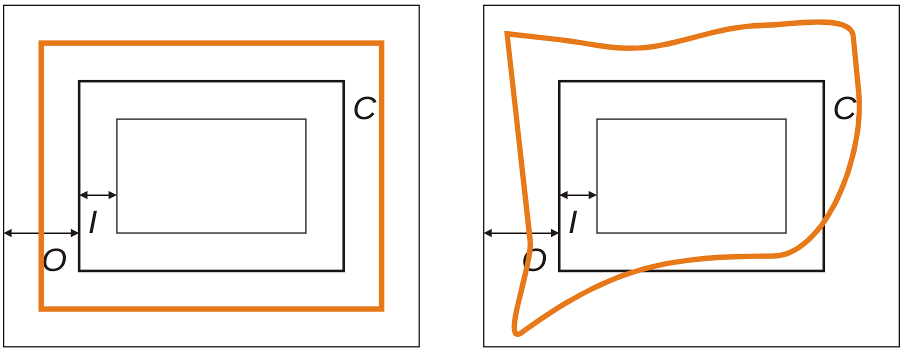

Figure 8. Simple adaptation: uniform scaling (left) - Adaptation with full relaxation (right)

If we relax the orthogonality constraints and attach tolerances to the vertices rather than to the whole shape, flexibility increases and allows for controlled deformation. Further relaxation concerns the integrity of the shape, i.e. the number of vertices. The ability to adapt by changing the number of vertices and hence sides means that an entity can create its own perturbations. Full relaxation of all geometric constraints leaves only the tolerances active, together with user-defined constraints, e.g. the area of the shape.

Autonomous, self-regulatory transformation is triggered by spatial relationships between fuzzy shapes, e.g. overlapping. As in analogue sketching, the vagueness of a boundary is instrumental for the resolution of conflicts. In canonical shapes with tolerances there are three cases of overlap: intrusion of outer zone, intrusion of inner zone and interruption of the shape. Each case triggers a different action. Intrusion of the outer zone is treated lightly, even if there is more than one intrusion in a shape. Intrusion of the inner zone has higher priority because it concerns the canonical form. Interruption of the shape is a serious violation, as it challenges its integrity and performance.

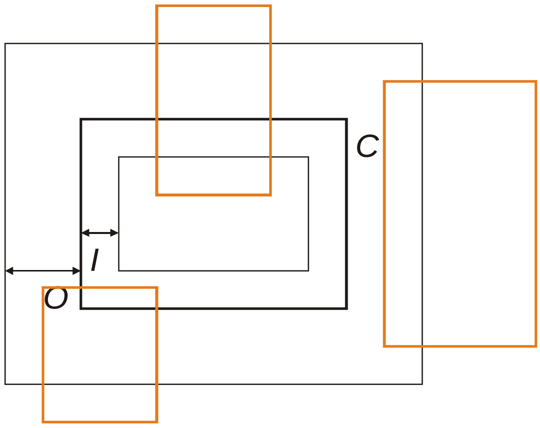

Figure 9. Overlap cases

The conflict resolution system that determines the response to such problems relies on criteria derived from the structure of the fuzzy shape, such as the range of fuzziness (a small range indicates low tolerance: a 'hard' object) and external constraints, such as the character of a space (use spaces are harder than e.g. horizontal circulation spaces). Put together they determine the *plasticity* of a fuzzy shape. When shapes with different plasticity degrees overlap, the softer shapes are more easily deformed but never beyond the minimum indicated by their tolerances. This minimum should not be equated with the inner limit. Soft shapes can be translated and deformed, provided that the basic constraints (e.g. area and topology) are not violated. When a soft shape reaches this minimum, the request for adaptation is passed on to the harder shape in the relationship.

In shapes described by their minimal and maximal values conflicts are treated in very much the same way. Lack of a canonical shape and the consequent unification of the inner and outer zones normally indicate a softer shape. Therefore, such shapes are generally subject to more deformation. Point sets behave in an altogether different manner. The actions stemming from the autonomy of the shape are delegated to the particles that describe its boundary. Each particle attempts to link itself to similar neighboring particles. Isolated particles die out. The remaining particles form groups indicating boundaries using chain coding (Freeman, 1961).

A final aspect of local intelligence and autonomy is the *filling-in* of leftover space. The informal character of the floor plan sketching means that space between entities (in particular spaces) can be left vacant. Also the outline of a floor plan is frequently vaguely defined. Soft shapes and shapes that are often amorphous, such as horizontal circulation spaces, attempt to fill in the leftover space, especially if it is small. This may compensate for losses that occur due to conflicts with harder shapes.

IMPLEMENTATION ISSUES

Fuzzy modelling is a straightforward concept that can be easily added to existing CAD and modelling systems in two, three or four dimensions, so as to make them appropriate for early design. Its ability to encapsulate many local constraints makes it a more economical alternative to parametrization and cumbersome constraint propagation networks. By supporting local intelligence, fuzzification simplifies communication and information management in a transparent manner. This largely due to probably the most important advantage of fuzzy modelling: in its capacity to localize problems and conflicts. A large number of minor decisions can be taken automatically on the basis of general constraints and local conditions. Finally, fuzzification helps correlate design representations with more abstract forms of design thinking. This is also relates to the main problem of fuzzy design modelling, namely that thorough understanding of domain problems and their possible resolution is an essential prerequisite to developing fuzzy symbols and models that perform effectively and reliably.

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THE STRUCTURE OF A GROUP DESIGN ROOM

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Abstract
The Group Design Room (GDR) is a research environment for exploring the combination of group process support with virtual design prototyping (VDP). The purpose of this environment is the analysis of a descriptive approach to the coherent representation of form, function, expected behaviour and projected performance, the integration of aspects at various design stages, continuity between stages, and interaction between aspects. In mode A, each aspect is allocated to a separate workstation of the GDR, which is operated by a specialist. VDP provides connections between the workstations, generally on an if-needed basis. The group process is assisted by a technical coordinator and managed by a design and decision coordinator. Development of a solution is based on an analytical, integral brief that incorporates legal and physical constraints, as well as on cases and precedents. In the V mode each workstation also accommodates a virtual expert for its aspect, while participants represent general interests. Also in this mode the GDR makes heavy use of cases and precedents from which partial solutions can be derived.

Keywords: Collaboration, group processes, interoperability, virtual prototyping.

COMPLEXITY AND GROUP DESIGN PROCESSES

One of the most striking developments in design thinking in the last decade has been the acknowledgement of group processes as a main aspect of complexity in designing. This represents a clear departure from traditional design studies and their focus on the individual designer (Chiu and Yamaguchi, 2001, Gross et al., 1998, Rosenman and Wang, 2001). It also forms a promising framework for the analysis of various factors that make designing so complex, from the concerns and specifications of each aspect and specialization involved in a particular project to the interaction between different specializations within the confines of a particular design stage or action.

Complexity is frequently approached negatively, i.e. as a cause of problems and conflicts that must be eradicated in order to achieve an effective design and an efficient process. However, complexity should also be seen as a source of innovation, creativity, reliability and performance improvement – especially in the framework of group processes (Demri and Orlowska, 2002). The coordination of constraints relating to a number of aspects returns a rich and responsive network that supports a wider and deeper exploration and analysis of problems and possibilities. In this network an action with respect to a single constraint can stimulate the development of design ideas, variations and alternatives on the basis of transparent relationships between aspects and global analysis and evaluation.

A primary characteristic of complexity in design processes is that, despite the daunting overall appearance, parts and elements can be perfectly legible, transparent and controllable. In other words, one may assume that each local problem can be safely and efficiently resolved when isolated to a particular aspect and a specific abstraction level. Complexity emerges when all relevant aspects, abstraction levels and local problems come together, mainly due to combinatorial reasons. However, even then local views (i.e. centred on a particular aspect or problem) usually remain reasonably well-structured and manageable. Moreover, these views tend to fall within the scope of specific disciplines, which are generally well equipped for handling local and partial problems.

This descriptive approach to design complexity is an alternative to the more common prescriptive or proscriptive approaches. These restrict the process and the products of designing to established, deterministic procedures and known solution areas (Koutamanis, 2001a). Such restrictions make the course and outcome of a process predictable and controllable but at a price: innovation and creativity are frequently explicitly sacrificed. They also make procedures cumbersome and time-consuming, as crucial features of a particular project may be suppressed in order to fit given frameworks, while general characteristics of these frameworks must be treated even if irrelevant or trivial. Prescriptive and proscriptive attitudes have often undermined information management, group process support and architectural creativity (Broadbent, 1988, Eastman, 1975, Helpenstein, 1993, Lawson, 1990, Maver, 1995, Warszawski, 1999, Briggs, 2004). Descriptive approaches avoid such pitfalls but tend to be "soft", more attuned to expert users and researchers than practitioners struggling with (superficially) routine problems.

Our exploration of the descriptive approach to design complexity focuses on the following hypothesis: complex problems can be subdivided into overlapping, interconnected segments that correspond to existing or emerging disciplines. By delegating responsibility for each segment to a particular discipline it is possible to allow for reliable management of information, effective decision-taking and analysis of problems and solutions at a variety of abstraction levels and from all relevant viewpoints. A main prerequisite is that the segments are connected in a coherent and comprehensive manner that allows local and global integration of synthesis and analysis.

The verification of such hypotheses requires not only new theories and methods but also new working environments, capable of supporting communication, interaction and decision-taking. The purpose of such environments should be to provide the means for: (a) implementing and testing new approaches and tools, and (b) understanding the often intricate relationships between aspects, disciplines and problems. The present paper describes the setup and early experiences with such a research environment, the Group Design Room (GDR). The direct inspiration for the GDR has been group design rooms, electronic meeting facilities aiming at helping groups address complex problems collaboratively, including brainstorming, concept definition and categorization and evaluation through voting techniques (de Vreede et al., 2004, de Vreede et al., 2002). The GDR aims at a similarly interactive exploration of complex, typically multi-actor, multi-criteria problems by adding facilities for design information management. This is by no means a novel idea. There have been several attempts at this combination with promising results in the area of collaborative design, most notably the iRoom (Fischer et al., 2002).

VIRTUAL DESIGN PROTOTYPING

Design information management in the GDR focuses on the representation of a design: the coherent, complete and consistent description and analysis of (a) the form and construction of a building, (b) the activities to be accommodated in the building (function), (c) the expected behaviour of the building, and (c) the projected performance of the building (i.e. the degree of matching between form, behaviour and function). In the GDR such information is integrated in virtual design prototypes (VDP) that underlie all design actions and transactions. A VDP supports integration of all aspects at any stage at appropriate levels of abstraction and permits a direct correlation of design documentation with analyses (Bloor et al., 1995, Ovtcharova and Vieira, 1995, Hollerbach et al., 2000, Bullinger et al., 1999). A VDP integrates analyses by linking analysis results to entity properties and analysis procedures to the relationships between entities (e.g. pedestrian circulation is expressed as the dynamic relationship between specific activities in a building and the spaces and doors used). This also implies that VDP has a strong preference for analytical simulations that generate detailed information.

The use of multiple abstraction levels in a VDP not only makes information available to various design stages but also supports continuity throughout a design process and the lifecycle of a building. This includes transitions between stages, e.g. backtracking to an earlier decision, as well as the use of precedents in anticipating design behaviour and performance even in the earliest stages. This makes possible the simultaneous treatment of design problems at variable abstraction levels. For example, crucial features of a space such as the openings usually require more attention than they receive during the early design stages because they relate to aspects usually considered in later stages.

Design information management in a VDP is open to several alternatives, from holistic or modular building models to distributed partial representations linked to each other by means of information standards. The only permanent prerequisite is that each discipline should have full and transparent control over its aspects. This makes the GDR amenable to most existing approaches, standards and techniques but not limited by any of these.

A MODE

In physical terms the GDR consists of a number of workstations for the participants, servers for shared information storage and background processing, communication and presentation facilities, including video and document conferencing. In the A mode, the basic form of the GDR, each workstation is allocated to a particular aspect and a corresponding discipline, such as architectural design, cost analysis or HVAC. Participants to an A mode session are experts from the subdomains and specializations relevant to the design problem in hand. Each workstation is equipped with the software normally used by the particular discipline so as to provide a familiar working environment and allow full control over programs and information.

Connections between the workstations are at the level of input and output of the software used by each discipline. This may involve a degree of redundancy, especially in the case of central models, as information processed by a workstation is a partial copy of these models. On the other hand, it also allows for direct comparisons between states, variations and alternatives, one in the central model and one in the workstation. When central models are not used integration of aspects involves the use of two to three partial models that represent primary views. This is achieved by importing relevant information from other aspects into two or three programs and linking these programs to each other with constraint propagation networks. In the GDR links are always dynamic: they propagate constraints from one part, aspect or program to the others automatically and as soon as a change occurs. Links are either hard-wired (i.e. predefined links between related entities and properties) or agent-based, i.e. make use of specialized autonomous mechanisms that collect relevant information and pass it on to the appropriate program (Lees et al., 2001).

Processes in the GDR are coordinated at two levels. At the practical level of computer technology a technical coordinator (TC) is responsible for maintaining connectivity between workstations, servers, projection and coordination facilities. This amounts partly to troubleshooting and partly to ad hoc just-in-time development of additions to the GDR systems in response to a new problem or insight. The TC ensures that interaction between aspects remains direct, flexible and transparent at all times on the basis of an unobtrusive information infrastructure. This also includes background information processing on behalf of an aspect, such as time-consuming dynamic simulations.

The second level of coordination concerns the content and flow of activities in the GDR. The design and decision coordinator (DDC) is responsible for guidance, conflict resolution and summarization. Group processes in the GDR are initiated by the DDC who typically invites one or two participants to provide a solution for a particular problem. The problem is defined by specific constraints (e.g. a brief) on a part or aspect of the design. At a high abstraction level they may also refer to the whole design (e.g. choice of building type). The development of solutions in the A mode seldom starts from scratch. Most problems are defined in an analytical, integral brief that brings together all client requirements. The cumulative experience of each specialization and of building design in general should be encapsulated in collections of fully documented cases and precedents.

The DDC determines which aspect receives the focus at any particular moment. This means that the corresponding participant takes the lead in the development of the design. The projection facilities normally copy the desktop of this participant. As information is processed by the leading participant, relevant results are propagated to the workstations of the other participants who explore related issues. The DDC should be aware of these explorations at all times, so as to be able to change the focus or halt the development of the design when a bottleneck emerges. Most conflicts between aspects or decisions become the subject of in-depth exploration and are resolved by consensus. In the case of a stalemate the DDC can use a number of options: proceed with two or more alternative solutions, make a preliminary choice that may be reversed later on in the session, pause for a cooling-down period, or terminate the session. At the end of a session each participant takes with him the information produced in his workstation and can continue working on the project at his own office. The coordinators produce an official report on the session, which includes the information on all workstations and servers.

V MODE

The V mode is based on arguably the ultimate form of a VDP: information on each aspect of a design is enriched with automated processing facilities that constitute a virtual expert, capable of responding to relevant input on the basis of analyses and case-based rule systems. This gives a VDP a limited reasoning ability that is adequate for the abstract information levels of early design, as well as for a number of frequently encountered problems. As in the A mode, each aspect and its virtual expert are accommodated in a separate workstation of the GDR. This makes the operation of the virtual experts transparent and controllable (also by real experts). However, the participants to a V mode session generally do not include real domain experts. Instead, they represent parties with a general interest in the project as a whole, e.g. property developers, authorities, clients, occupants, architects or design competition jurors. The problems handled in the V mode are typically elliptical and highly focused, such as the choice of housing types or land uses in a new development area.

The two coordinators are also present in the V mode. The tasks of the TC remain unchanged, while the DDC has the added responsibility of case and precedent selection, normally as a response to queries and suggestions made by participants. A process in the V mode is usually initiated by a primary question, i.e. one of the main constraints in a brief or design. The DDC presents a spectrum of possibilities, preferably illustrated by means of relevant cases and precedents. Each of these is analysed by the virtual experts. The analysis results are made available to the participants who are free to move from one workstation to another, depending on their interests and priorities. The DDC remains responsible for the focus of the session (solution, aspect or participant).

The designs produced in a V mode session can be abstract design concepts typical of early design or collections of parts form precedent solutions. In both cases the products are linked to the analyses and evaluations of behaviour and performance available in a VDP. As a result, choices and decisions can be reasonably consistent and representative of the possibilities of each case. However, there can be no guarantees concerning the coherence of the designs. Extensive post-processing is generally required in order to transform the results of a V mode session into a workable departure point for a design process. Arguably the best result of V mode is not a complete design solution but a partial but coherent specification that can be expanded into the starting point of a design process.

EXPECTATIONS AND EARLY EXPERIENCES

The main question to be answered by early experiences with the GDR concerns its suitability to the experimental implementation and evaluation of hypotheses relating to descriptive approaches to design information management. The first of these hypotheses is the distribution of information control in group design processes (see above). The evaluation of GDR suitability was based on the analysis of user experiences, as well as more objective information measures, primarily recall (the ratio between the number of relevant items and the number of all items in the information system) and precision (the ratio between the number of relevant items and all items handled in a specific action).

Early experiences with the GDR are limited to the A mode and sessions involving no more than four aspects. The maintenance of each aspect during an A mode session requires substantially more time and attention than in conventional design meetings. Frequent short pauses allow participants to gather their thoughts and catch up with their information processing. Well-structured representations and fully automated analyses contribute to the efficiency of information processing and allow for the reflection and interaction the GDR should stimulate, especially if they are equipped with error correction mechanisms (Koutamanis, 2001b). Communication and constraint propagation between aspects were experienced positively and did not lead to information overload, as most changes were incremental and had a limited effect on the design or an aspect. The users generally felt in control of the information and software in their particular workstation. Reaction times verified this. Participants were also able to defer processing of effects on the design, i.e. were able to retain an overview of design development and of relationships with other aspects, while concentrating on current priorities.

Precision and recall were measured for specific actions and connections (e.g. evaluation of floor areas with respect to the brief) and for a whole session (cumulatively in the blackboard system used for agent communication and coordination). In a comparison that remains to be validated, both local and global measurements showed no significant deviation from asynchronous communication between similar aspects in conventional design projects. This suggests that working in the GDR does not add much to the burdens of each aspect or alter the structure of design interaction and communication.

The measurement of precision and recall, as well as user satisfaction, also relate to the means of design information management. Explorations of building information models (BIM) and information exchange standards such as the Revit BIM and the Industry Foundation Classes (IFC) of the IAI had rather mixed results, an experience shared with similar but unrelated research projects (Rosenman et al., 2005). While the availability of usable symbols organized in understandable classifications was a positive factor in designing, information management and communication, symbols were found generally underconstrained and tolerant of inexcusable user errors. Moreover, there are yet no built-in mechanisms for automating constraint propagation (i.e. for making a sybol automatically responsive to its context). As a result, current BIM implementations offer no secure basis for VDP that would reduce maintenance problems in extensive design information systems (Hovestadt and Hovestadt, 1999).

An alternative also explored in the GDR is modular hierarchical representations (Koutamanis, 1997). Such representations have a rather long history in areas such as computer vision and image processing (Marr, 1982, Rosenfeld, 1984, Rosenfeld, 1990). They support transition between design stages and distinction between aspects in an appropriately fuzzy manner. The use of modular hierarchical representations also bridges gaps between aspects that emerge as a result of differences in symbolic structure and abstraction (as a result of different priorities). For example, most building services are represented at the level of inlets and outlets or facilities and controls, while architecture and construction are also interested in the integration of related infrastructure. The common interest in spatial and functional performance is generally sufficient for communication and decision-making but does little to structure the subsequent processing of effects and consequences. The approach used in the GDR is to form expectations concerning such effects and consequences, e.g. identifying building elements and components that can be used for the integration of services. This allows deferment of details to later stages and makes communication can be transparent and open to future developments without adding unnecessary or premature tasks to stages and aspects.

Dynamic links between software proved transparent and more efficient than file exchange. They allowed delegation of information maintenance and archiving to each individual aspect, as well as selectivity in communication: each participant was able to determine which constraints from other aspects were relevant to his own functioning and tasks. The dynamic links often operated on an if-needed basis rather at regular intervals. Communication was triggered either directly by a participant who initiated a change in the design and passed on relevant effects to other participants, especially if a response was required, or indirectly through a blackboard messaging system where changes were reported to all participants. Aspects concerned with the change requested for further information through the appropriate dynamic links. A consequence of the preference for communication on an if-needed basis not foreseen in the original blueprint of the GDR is that a VDP should be equipped central registration of actions and transactions (Fischer et al., 2002) which complement versioning control at each workstation.

Another deviation from the original setup of the GDR is that in the A mode an aspect may require two experts to operate the corresponding workstation jointly. The pace of a session and the necessity to search in background information often proved too much for a single user, despite the liberal use of pauses. Two equally capable operators per workstation are considered to be preferable to a single expert with an assistant, as the latter would be inevitably restricted to menial tasks and would increase the distance between the GDR operation and the actual designing or decision taking.

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DESIGNING TO TARGET COST: ONE APPROACH TO DESIGN/CONSTRUCTION INTEGRATION

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Abstract
One approach to a more integrated construction delivery process is the concept of 'designing to target cost' of which the first examples of application within a lean construction framework have recently been seen. This paper introduces the main principles of the design to target cost method and discusses the applicability of this approach to construction. The low degree of organizational and technical continuity from one construction project to the next limits the applicability of the design for target cost approach when compared to its origin in product development of mass manufactured artefacts. The approach can, however, be applied as a way of substantially involving the production organisation from the earliest phases of schematic design and thus contribute to enhanced value and reduced waste for the overall project delivery as well as for the many assignments of which it is ultimately composed. It can be argued that design to target cost may also provide a frame for developing the supply chain towards better coordination and collaboration. Thus methods of design to target cost may serve to facilitate the development of a more integrated supply chain.

Keywords: Collaboration, design to target cost, lean construction, supply chain integration, value engineering.

INTRODUCTION

Construction is a project-based production activity exposed to various factors of uncertainty, complicating cost estimation, production planning and management and the control of cost development. A major problem to managing costs in construction projects is that final costs are usually not known until relatively late project stages where many parameters have become fixed. This often leaves project management with a very limited range of adjustable parameters through which action can be taken to prevent costs exceeding budget, or to limit the wider (project) consequences of specific cost escalations. Significant conflict often arises when project participants are faced with the unavoidable need for dealing with the allocation of the unforeseen burden. A typical scenario could include the need to settle for one or several of the following outcomes:

- Acceptance of budget escalation - which includes the need to identify the participant(s) bearing extra costs,
- Acceptance of delayed project completion or postponement of the meeting of agreed milestones,
- Acceptance of design changes with technical consequences undesirable to one or more of the members of the supply chain,
- Acceptance of design changes with undesirable consequences for design intent and value delivery.

Frequently cost escalations end up involving not only project participants but also the system of justice if participants fail to reach agreement on responsibility and further consequences. Such action adds no value to the project concerned and is desirable to solicitors only. One conclusion to be drawn from such experiences is the need for project-scoped cost management techniques addressing early design phases where the scope for cost-restricting action is considerably larger than during detailed design or during production. One cost management technique addressing early design phases is that of *designing to target cost*. This method is originally a technique for product development evolved by Japanese lean manufacturers seeking to develop products with potential for continuous reductions in manufacturing costs throughout the product's market life in order to stay competitive (Cooper & Slagmulder 1997; 1999). Today the method is well known within lean manufacturing but is less explored in the area of construction. It has some obvious constraints for use in the built environment, but many of its principles are fully applicable to design and construction. Despite its origin as a tool for managing costs the method may bear an additional potential for strengthening supply chain collaboration and innovation in construction while enhancing value delivery and fulfilment of design intent. It is from this perspective the method will be discussed in this paper, which is written in connection to the author's ongoing Ph.D. studies on integration of (lean) design and construction. The primary aim is to introduce the *basic principles* behind designing to target cost and to inspire further studies, experiments and debate regarding integrated approaches to design, construction and supply chain collaboration.

A METHOD FOR DESIGNING TO TARGET COST

The design-to-target-cost method builds on the principle of making costs and cost data direct inputs to the design process instead of an outcome of it. It is in other words an example of the more general issue of designing to target characteristics, sometimes referred to as 'design for x' (DfX) (Cooper & Slagmulder 1997; 1999). In Japan the concept evolved as a strategy for developing products with a higher potential for meeting the manufacturer's profitability objectives throughout the product life time (Shingo 1988; Cooper & Slagmulder 1997; 1999). According to research by Dekker & Smidt (2003), applied techniques similar to the ones described by Cooper & Slagmulder are likely to be found in many manufacturing companies around the world. In an example from construction, Ballard & Reiser (2004) draw attention to three primary challenges when designing to target characteristics:

1. how to incorporate the relevant specialists in the design process,
2. how to make trade-off decisions between the characteristics, and
3. how to drive design decisions to achieve targets.

While Ballard & Reiser limit their focus to exploring of the third of these issues, this paper is written with the intention of contributing to the exploration of the first.

Setting cost targets

Target costing methods are basically a structured way of identifying the costs and quality that must be achieved for a product to be successful on the market while bringing a satisfactory return. Traditionally profitability has been estimated through the equation:

Expected selling price – production costs = profitability level

Target costing takes a different point of departure by first deciding on what profitability level will be satisfactory which hence presents the equation:

Expected selling price – profitability level = target cost

When this paraphrasing of the equation makes a difference to practice it is due to what some refer to as the *cardinal rule of target costing* (e.g. Cooper & Slagmulder 1997; 1999) prescribing to never launch a product above its target cost. This rule can only be violated under very special circumstances where launching a product with dissatisfactory earning prospects is considered necessary to gain or protect a certain desirable market position or because the product itself is a requirement for another product with satisfactory profitability. An example of the first situation could be a manufacturer of consumer electronics who for strategic reasons needs to offer a competitive model within all price categories of a certain type of products (e.g. cellular phones or cameras). A well-known example of the second situation could be the razor market, where a razor in itself is likely to be completely unprofitable but constitutes a necessity for selling highly profitable razor blades and thus make an overall satisfactory return. However the general principle is that if keeping within cost targets must be given up, the product will not be launched. By this method costs, similar to functional requirements, become well-defined design requirements from the very beginning of the product development activities.
An important part of the philosophy is to set the fixed targets at a level that, despite being lower than current abilities enable, is nevertheless realistic to achieve and thus worthwhile the effort. The largest potential of target costing lies in a collaborative supply chain approach to meeting all cost targets and hence satisfy all supply chain members' demands for profitability. From this perspective the setting of cost targets is largely a matter of identifying what is realistic, but yet sufficiently low to motivate innovation and reengineering of inter-organizational processes among the members of the supply chain.

Multi-level target costing
The principles of setting and working according to cost targets are applicable to sub-levels as functional systems, individual components and even parts of components. At sub-levels cost targets are established on the basis of the overall product target cost. Defining these is the next step in the target costing procedure.

Target cost = target cost (component/subsystem A) + target cost (component/subsystem B) + ……

Through the setting of target costs on the basis of market selling prices the company facing the cost pressure in the market place can transmit this cost pressure to its suppliers, sub-suppliers and so on. Multi-level target costing procedures can be applied to the extent that long-term relations exist beyond the level of 1st tier suppliers, i.e. not only to suppliers but also between suppliers, sub-suppliers, and their suppliers etc.
By designing according to these cost targets it is possible to concurrently identify solutions that fulfil design intent while enabling an appropriate production process through which manufacturer, suppliers and sub-suppliers can reach their profit targets. Under this procedure cost targets are not dictated solely by the purchaser or achieved through traditional competitive tendering. Targets need to be negotiated in order to identify realistic expectations based on collaborative search for improved methods of production and/or procurement.

Grouping of cost targets
Individual targets for components/tasks can be grouped so that individual costs, while not their sum, are allowed to exceed targets. This serves to provide a higher degree of flexibility and thus increase the scope for harvesting existing potential for cost reduction. Just as important is that this motivates inter-organizational collaboration about identifying and exploiting synergies across the company boundaries within the supply chains.

Supply chain relations – a critical parameter
It is obvious that successful application of such procedures require strong collaborative supply chain relations with an 'open book' policy to secure transparency of cost data. The method builds on acceptance of the assumption that the organisations involved no longer compete as individual companies but as members of supply chains competing against other supply chains, as argued by e.g. Lambert & Cooper (2000). With this method it is common practice to work with a relatively small number of suppliers with whom continuous relationships are built. To engage suppliers in pursuing further potential cost reductions they must feel confident that they themselves will benefit from their efforts and that contracts are not subsequently awarded to their competitors to harvest the benefit of this work. Continuous relations are a prerequisite for achieving further cost reduction through re-engineering the supply chain's production of sub-systems and components (or the execution of tasks), and move or merge assignments across company borders to benefit from synergies. These and other aspects of target-costing require high levels of trust, which the method seeks to build on factors of transparency, continuity and through the establishing of common interests by applying the 'all for one' principle of not accepting excess of the target cost, which thus guarantees individual supply chain members a satisfactory profitability. In the assumption that a given technical or cost advantage will be very temporary, abilities of learning as a team are an important aspect. An aspect which is critical when having to continuously reduce costs after the launching of a product in order to remain competitive throughout the span of the product's time on the market. In this perspective past or current performance of potential suppliers is less relevant than that of their potential for further development and improvement. Following this argument, suppliers should not simply be evaluated as individual firms but (from a system's perspective) as sub-supply-chains; and their potential be considered from the perspective of developing the downstream relations to sub-suppliers and their suppliers.

Cost reduction targets and product life profitability
Developed for repetitive production the method operates with targets for cost reduction during the expected manufacturing period. Reduction targets are a consequence of the expectation that competition from new products and price pressure from competitors will drive down selling prices over the manufacturing lifespan of the product. For a product's profitability to remain satisfactory there must thus be a continuous reduction in manufacturing costs. With the pressure from an annual cost reduction target, the supply chain is faced with the need for developing products and manufacturing processes that (in addition to meeting the original cost targets) bear sufficient potential for further reduction of production costs, thus enabling the product to remain competitive without violating the profitability level satisfactory for manufacturer and supply chain. It is important to realise that the method does *not* aim at reaching the 'lowest possible cost' but focuses on reaching an explicit cost target. The crucial factor for success is whether the supply chain

manages to continuously comply with its cost reduction targets throughout the period of which the product is intended to be on the market.

Early stage value engineering

Value engineering (VE) techniques is an essential tool in the target costing approach. To some designers the term *value engineering* may have a negative ring as it describes activities aimed at cutting costs; cutbacks which many designers have experienced to include 'engineering away' features representing value to some stakeholders and which designers have structured their approach and work in order to deliver. VE in its purest form is essentially a tool to *cut costs out of a design* after realising that the production will be too expensive, while design-to-target-cost is aimed at *designing costs out of a product*. This 'upstream approach' is pursued by involving suppliers (internal and external) throughout all design phases in order to get immediate cost feedback, so that VE techniques can be applied from the earliest conceptual design stages when designers have the best possibilities for choosing alternative solutions that meet established targets for cost as well as quality. This method is intended to help avoid ending up with an undesirable need to severely compromise value delivery and design intent through cost-cutting exercises during stages when it is too late to change some of the basic concepts on which the product design is developed if these are found to cause budget overruns.

APPLYING TARGET-COSTING TO CONSTRUCTION DESIGN

Construction design can be considered a sub-category within a more general framework of product development (Kagioglou *et al.* 2004). The philosophy of developing designs through extensive use of target-costing principles is in principle fully applicable to construction design. Within the framework of construction few examples of designing to target cost have been studied and reported. Action research into two British pilot projects where target costing procedures were applied, with limited success, found that existing practices of collaboration and cost estimation along with norms and culture of the UK construction are a barrier to satisfactory exploit the potential of target costing (Nicolini *et al*. 2000). The study suggests that a fully-fledged target costing system, with all its ramifications, can only be achieved with sufficient time and considerable effort being invested in supply-chain relationships together with improved methods of collaborative cost determination. Kern & Formoso (2004) introduce target costing as part of an integrated application of various cost management tools to construction. Primarily based on previous publications Granja *et al.* (2005) introduce cost reduction targets (using the term 'kaizen') and call for further case studies and research into theory and practice of applying the method to construction. Ballard & Reiser (2004) discuss a case covering the design-build delivery of a US$ 12 million college sport facility, where designing to target cost was applied to enhance value generation within a given budget while managing costs for the contractor. The latter authors mention that methods for designing to target cost are likely to be more used in some form in construction design, but without being well documented. Arguing for a adopting a more systematic approach to design for target cost in construction, Ballard & Reiser proposed five next steps for research into (construction) design to target cost: *descriptive research, translation of concepts and techniques from other domains, determining appropriate applications of target costing in construction, understanding the change in roles and relationships*, and, *understanding the conditions for producing a target cost*. While all three publications apply a cost management perspective, this paper will deal primarily with the perspective of using the method as a framework for collaborative design to enhance value delivery and innovation. Ballard & Reiser (2004) warn against mistaking 'target costing' and 'designing to target cost' for *target cost contracts* which in a UK government publication was found referring to a specified way of sharing deviance from actual and target cost between contractor and client.

Preconditions

Design-to-target-cost requires that all design phases are undertaken collaboratively with strong engagement from all parts, e.g. designers, contractors, subcontractors and suppliers. This requires closer relationships in the supply chain and also demands a different way of inter-organizational working and collaborating. Collaborative design requires much more than enhanced communication and the design process must be structured and managed to enable reliable cost feedback on the right development stages. As designers are known to take very different approaches to the design process (Jones 1992; Lawson 1997) this may require considerable experimentation and learning to achieve in practice. Suppliers must be capable and willing to adapt to different procedures for working with upstream customers and downstream sub-suppliers, which implies social and organizational consequences as other fundamental changes in business processes. The method is obviously sensitive to changes in client wishes or demands. Efficient application thus requires an efficient briefing process and 'stable' client decisions. Working with design solutions that are open to fundamental changes, dependent on cost feedback, also requires a client willing to progress with a less well-defined schematic design and who possesses the resources to engage over a longer period of time when durable design solutions are gradually identified (Brandon & Powell 1984).

Constraints for the method's application to construction

The target-costing method is developed for repetitive manufacturing, while construction in general is a one-off production. Naturally this limits the potential of continuously driving down costs through permanent targets for cost reduction during the production phase. It should however be recognised that construction often bears a high degree of repetition and that there often are considerable repetitions from one project to another where reduction targets could come into play as a framework for improving design. Working under pressure to finish new design assignments in a short time may take development resources away from efforts to optimise or re-engineer production processes. If approaching construction design as an activity to be optimised independently there is a risk that target costing may not succeed to satisfactorily addressing overall project performance.

An obvious constraint to design-to-target-cost appears in the case where a project's conceptual design has been predefined through the outcome of an architectural contest, thus limiting the scope for the method's application. Also certain (public) regulation may provide problems for the application target costing procedures. A critical aspect is the liberty of assigning contracts to suppliers without being subjugated by rigid requirements for procedures of competitive tendering or other regulation de facto preventing supply teams to collaborate in an integrated way under long-term relationships.

NEW OBJECTIVES FOR DESIGN-TO-TARGET-COST IN CONSTRUCTION

Designing to target cost is essentially a method for managing the development of (production) costs. It is not unlikely that the pure cost management perspective will be the strongest motivation for further adopting the method to construction design, as in the example reported by Ballard & Reiser (2004). It can however be argued that the method also possess a potential for facilitating a development towards a more integrated construction delivery process enhancing not only cost management but also value delivery and the development of the construction supply chain.

Developing the construction supply chain through designing to target cost

The method of designing to target cost builds on establishing long-term inter-firm relations enabling the supply chain to work in a more integrated way with design as a collaborative activity. While there are other methods and approaches for involving the downstream supply chain in upstream design activities, it is characteristic for design-to-target-cost that the approach offers the combination of a methodology, a strong pressure for engagement and collaboration, and a common interest in reaching the cost targets (since these are I: demands for project continuation, and II: the mechanism ensuring that the individual supply chain members make a satisfactory return on the project). Since return targets are the very basis for the cost targets that serve as criteria for project continuation, successful compliance with these cost targets is the prerequisite for every individual participant's performance. Thus the method – in principle - provides participants with a strong incentive for supporting all other parts involved in achieving their targets. Motivating participants for actively searching synergies by moving or merging activities across company borders within the supply chain is enhanced by the aspect that while tasks, assignments and turnover may be shifting hands, this is done to support the meeting of defined return targets for all participants. 'Hand-offs' between assignments and supply chain members is generally critical to production performance (Shingo 1988; Hopp & Spearman 1996; Koskela 2000). One could hope that a framework, in which participants are encouraged to optimise hand-offs, may similarly serve to increase integration while decreasing uncertainty and risk. One critical aspect needing further attention is the management of the remaining cost uncertainty that cannot be eliminated. How is this best absorbed? And are the traditional use of various contingencies on subsystem level the most appropriate solution when seeking to apply a pressure for process development and innovation while preventing sub-optimisation? Long-term relationships may considerably stimulate both motivation and abilities for participants to engage in such development activities, but there is a need for further exploration into the extent that designing to target cost can be implemented in temporary project organisations. The method's potential for facilitating development of the construction supply chain deserves further attention in experiments and studies.

The innovation perspective

Construction has often been blamed for unsatisfactory levels of innovation (e.g. Egan 1998). An important aspect of the design-to-target-cost-method is the pressure for innovation in processes and technical solutions in order to meet targets and/or cost reduction targets that cannot be achieved merely through optimising tasks individually. Collaborative design in combination with long-term inter-firm relationships can provide circumstances advantageous to production feedback, double-loop learning and the building up of shared competencies. Additionally it may serve to motivate a more structured approach to common development activities on issues that may require a perspective longer than a single project. Design-to-target-cost as a framework for innovation activities would thus be an obvious focus of future studies.

Value delivery

The method described in this paper can also be considered as a set of design principles strengthening the information basis on which design decision is carried and thus stimulate the possibilities for comparing different design decisions in respect to their overall value/cost consequences. This of course under the precondition that the time required will be allocated to this activity. This demands that efficiency of building designs is viewed in a perspective wider than just in terms of resources spent on developing the individual project's design. Producing individual designs should in this regard be considered a product development activity that, in synergy with other designs, is to improve delivered value on future projects. If succeeding to reduce uncertainties regarding cost consequences and production constraints, designers will be in a more favourable position for enhancing value delivery for client and stakeholders and the design intent will be less exposed to the risk of being compromised by later cost-cutting exercises.

CONCLUSIONS

The principles of designing to target cost are in principle applicable to construction design and may, in addition to serving as a cost management tool, provide an alternative framework for developing construction supply chains towards more integrated inter-firm relations and activities. The method can also be seen as a methodological framework for conducting innovation activities or as an approach to enhancing the relationship between value delivery and cost. Little research into this method's application to construction, especially from the perspective of enhancing innovation and supply chain development, has been reported and there is a need for more comprehensive studies of its applicability and potential within the built environment.

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CONTRIBUTIONS FOR THE INTEGRATION OF DESIGN AND PRODUCTION MANAGEMENT IN CONSTRUCTION

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Abstract
Product Development Process (PDP) has become an important research topic in construction since the 80's. However, there are few research efforts focusing on understanding the integration between design and production planning and control. This paper discusses how to plan and control the design process in construction through the use of the Last Planner System. It is based on four case studies carried out in industrial and commercial building projects. The main proposition of this investigation was to adopt the Last Planner System for the design process and to explore links between design and production management on site. Both quantitative and qualitative data were collected. The main conclusion of this study was that the Last Planner System provided some key support for integration of design and production management on site.

Keywords: Design management, last planner system, product development process.

INTRODUCTION

Until the 80's design was often mentioned in the literature as a small part of the research and development (R&D) function[3] of firms or as a supporting activity for manufacturing. However, design has grown in importance due to the continuous increase of the complexity of products and due to changes in the market. This evolution has demanded more integrated approaches to the PDP, especially in global, intense and dynamic competitive environments. According to Prasad (1996) and Koskela (2000), concurrent organisation of product development emerged in the mid 80´s aiming to reduce project lead-times as well as to improve products from the point of view of both internal and external customers. For that reason, the implementation of concurrent engineering (CE) has been widely reported in several industrial sectors, such as aerospace and automotive. In the construction industry, this trend has helped some market segments (e.g. the commercial and industrial building sector) to achieve better results, although the complexity of project management has been increasing.

The difficulties of managing processes have increased the importance of developing research related to planning and control. In construction, the Last Planner System, developed by Ballard and Howell (1998), has been successfully applied to the management of production in different countries. Despite its positive results in production, only a relatively small number of studies have been undertaken on the application of the Last Planner System to the design process (e.g. Miles, 1998; Tzortzopoulos et al., 2001). However, those studies have not explored the integration between the design and production planning and control processes. This paper discusses how to plan and control the design process in construction through the use of the Last

[3] A function (in organizational terms) is an area of responsibility usually involving specialised education, training, or experience. The traditional functions in product development organisations are marketing, design, and manufacturing (Ulrich and Eppinger, 2000).

Planner System. It also explores possibilities for integrating planning and control systems used for both design and physical production.

BACKGROUND

Different authors have approached the Product Development Process from different perspectives, adopting different concepts and scopes. For the purpose of this study, PDP is defined as the inter-functional process that starts with the identification of a market opportunity and ends with the analysis of the product's performance in use. The evaluation of the performance in use is necessary to provide feedback to the development team through information that can help improving the team's performance in the development of future products. In this context, the PDP functions cannot be developed separately. This means that, apart from the relations between internal disciplines of each function (e.g. architectural, mechanical and structural design), the inter-relations between functions have to be considered, resulting in a huge and complex process.

Many managerial problems arise due to the complexity of the PDP. Therefore, to manage such a process poses many difficulties, dependent on the type of product, service or company. According to Clark and Wheelwright (1993), this is due to a fundamental problem: managers generally fail to plan skills and resources, to define project proposals appropriately, and to integrate different functions used by the company. Aiming to assist both designers and managers, some initiatives have been developed (e.g. Process Protocol, Analytical Design Planning Technique, Concurrent Engineering and Last Planner System). As the adoption of the Last Planner in fast, complex and uncertain projects constitutes the proposition of this research, both CE and the Last Planner System are briefly highlighted:

Concurrent Engineering: despite a considerable number of publications (e.g. Prasad, 1996; Kamara et al., 1997), CE has still been described as a set of principles and methods. For the purpose of this study, CE is defined as an approach that considers that PDP activities can be developed in parallel, in a simultaneous way. It aims at constantly readjusting the timing of both linear and sequential processes, to make all stakeholders aware of all the activities to be carried out from the start (Prasad, 1996). According to Kamara et al. (1997) CE is very useful in dealing with the problems faced by the construction industry. Those authors also stress that its effective application must consider certain specific construction characteristics (e.g. there are difficulties related to the involvement of all stakeholders at the front-end).

Last Planner System: this system is based on the hierarchical division of planning and control into different decision-making levels (e.g. long, medium and short-term)[4]. Despite problems related to it effective implementation, the utilization of the Last Planner has provided successful results in physical production management and promising results in design management.

In production management the aim of the long-term production planning is to establish production goals, i.e. main process flows and production rhythms. The aim of medium-

[4] The hierarchical division is still a research topic as discussed in Ballard and Howell 2003.

term production planning is firstly to establish a link between the long and the short-term planning levels. Secondly, but not less important, the objective is to identify and remove constraints. In order to do that, the activities must be planned a period of time in advance (e.g. three weeks). In the short-term production planning, the aim is to guide the production process on the construction site. On this level the only activities programmed are those for which constraints have been eliminated and which are within a planning horizon below the medium-term horizon (e.g. one week). The performance of this planning level is measured by the indicator “Percentage Plan Complete” (PPC), which is the quotient between the total of activities fully completed and the total of activities programmed. Causes of non-completion are analysed in parallel.

The suitability of the application of the Last Planner system to design is still under investigation. However, it is assumed that the hierarchical planning levels would be the same, and some general adaptations to design have been proposed. At the long-term, planning should start with the establishment of milestones for the completion of design tasks (Miles, 1998). These milestones should be set according to the sequencing of PDP phases (Tzortzopoulos et al., 2001) or they should be set according to physical production priorities (Miles, 1998). Medium-term design planning should start with detailing the design master plan, considering a planning horizon of a few weeks ahead (Miles, 1998). Important roles of this level of planning are the identification and removal of constraints on time and the planning of the activities that should be carried out in parallel at the short-term level. Although it is considered essential, there are few reported experiences in medium-term project planning. In short-term design planning, the aims are to plan and control the activities that can be undertaken. In order to do that, it is necessary for the people involved to negotiate the activities programmed, to define the responsible parties, to define the deadlines for the execution of the tasks (Miles, 1998).

RESEARCH METHOD

Four case studies were carried out in a medium-sized (approx. 150 employees) construction company located in Porto Alegre, Brazil. This company is usually involved in industrial, commercial and hospital projects. These projects tend to be very fast, complex and uncertain – some of them consist of the refurbishment of operating facilities. In general, the company’s responsibility includes managing subcontracted designers through the design process, and managing own as well as subcontracted work force. Despite the company has an established partnership with subcontracted designers, they contract other professionals when suggested by the client.

The following research techniques were used in this research: (**1**) literature review of both theoretical and empirical research concerning PDP management and, planning and control; (**2**) participatory observation of design and production planning and control meetings (in all 57 short-term production meetings; 57 medium-term production meetings; 25 design meetings). The role of the researcher in design and production meetings was to collect data related mainly to decision making. A spreadsheet was used to register the participants, decisions made and problems concerned the use of the planning system; (**3**) site observation of problems occurring due to the poor integration of design and construction, in order to identify the root causes of the problems observed on the construction site. In order to do so, the researcher visited the construction site weekly.

A camera was used to register the empirical evidence; (**4**) 15 semi-structured interviews with managers and designers (02 with production managers and 13 with designers of different disciplines); (**5**) document analysis, e.g. plans and performance of the design and production teams; (**6**) observation of internal seminars (with the research team) and external seminars (involving company managers and supplier representatives).

Data analysis related to design and production integration was based on the identification of design tasks in conducting production planning and vice versa. In relation to the applicability of the Last Planner system for design planning and control, the variables considered were the percentage of design tasks completion, the number of unfinished production tasks due to design problems, and designer's perception of usefulness and utility.

DESCRIPTION OF THE CASE STUDIES

Case Study 1 (CS1)

CS1 involved two industrial projects. The first project was the refurbishment of an existing two-storey building of 831.96 m^2 and a 1,607.05 m^2 extension. The project duration, which was contractually established, was six months for the development of both design and production. The second project, carried out for the same client, was the construction of an industrial laboratory of approximately 400m^2, in which the design was considered to be complete. The contractual duration established for its completion was three months.

In the first project, weekly meetings were held to plan and control long, medium and short-term production as well as short-term design. The participants of the short-term design meetings were construction company representatives, client representatives, all designers and key-suppliers (usually 20 people). The planning was conducted by the construction manager and the plans established with the agreement of all people involved[5]. At the medium-term production meetings, participants included the production manager, selected system suppliers and, when necessary, selected designers and client representatives. Figures 1 and 2 represent the spreadsheet developed for the construction company to plan and control the medium-term production plan.

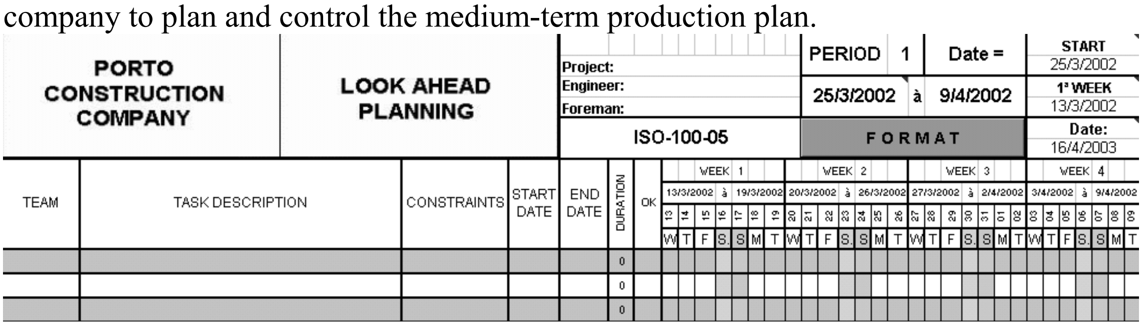

Figure 1 – Electronic spreadsheet for medium-term planning

[5] The construction managers were responsible to apply the Last Planner System in all case studies.

PORTO CONSTRUCTION COMPANY		CONSTRAINTS LIST		Project: Engineer:		REMOVAL LIMITE DATE WEEKS				PERIOD	1	ISO-100-05 Date: 28/02/02
Nº	CONSTRAINT DESCRIPTION			RESPONSIBLE	REMOVAL DATE	13/03 a 19/3 W1	20/03 a 26/3 W2	27/03 a 2/4 W3	03/04 a 9/4 W4	FORECAST COST	OK (Y or N)	PROBLEMS
1												
2												
3												

Figure 2 - Electronic spreadsheet for constraint analysis

Once identified, the design constraints were made clear by the production manager to the designers in the short-term design meetings. The design constraints were split into tasks for designers to carry out. Figure 3 demonstrates an example of the short term plan spreadsheet used in CS1. By the utilisation of this spreadsheet, plans were established in terms of task, time for task development and responsibility for the task. Problems related to task non-completion were also listed.

PORTO CONSTRUCTION COMPANY		WEEKLY DESIGN PLAN	Project:	Week no: ___________							Quality Control No.______
			Engineer:	Period ___/___ to ____/____							
			Coordinator:	PPC: ______ TOTAL:_______							Date: ____/____/ ___
Resp.	Exec. 100%	Task		Week 1							Problems
				W	T	F	S	S	S	T	

Figure 3 – Design short-term spreadsheet

Figure 4 represents the relationship between the planning and control levels established for the first project.

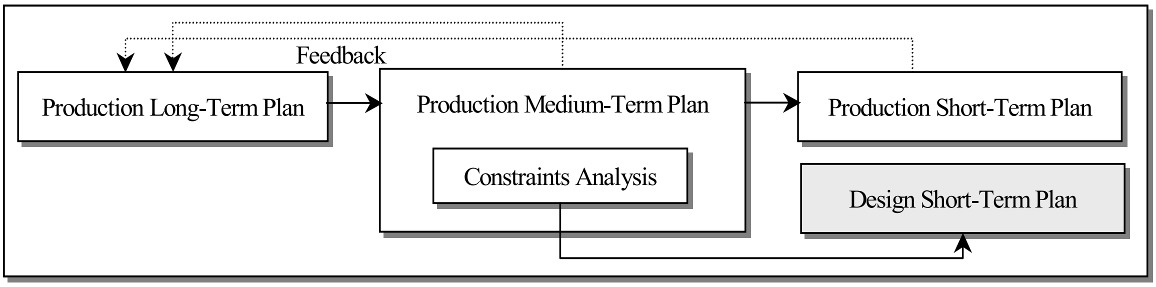

Figure 4 – Relationship between production and design planning levels in CS1

In the second project no design meetings were held. Medium and short-term production meetings were held on a weekly basis.

Case Study 2 (CS2)

CS2 focused on a project consisting of nine buildings on two construction sites near the coast of Rio Grande do Sul, Brazil. In total, these buildings had an area of approximately 6,200m^2 and were designed for the storage of oil pipes and safety training of the client's employees. The duration established for the completion of the buildings was five months. In CS2, the design was considered to be complete, except for the mechanical and electrical (M&E) and pre-cast reinforced concrete structural designs.

The medium and short-term production meetings took place on a weekly basis. Constraints related to design were released to the designers by e-mail or by occasional meetings. The production manager held occasional meetings with each designer separately. Based on the analysis of SC1, the production manager tried to plan the design at a medium-term level. Despite the manager's efforts, the medium-term plan failed because design meetings were held between the production manager and each designer separately, and interaction between different design disciplines could not be facilitated.

Case Study 3 (CS3)

CS3 involved the monitoring of the elaboration of the proposal for the construction of a commercial building of 4,560m^2. The design had been developed under the supervision of an architect hired by the client. In order to reduce production lead-time and costs, various design reviews and alterations were proposed by the construction company.

The planning and control system proposed in this study is represented in Figure 5. As the construction company had not yet been contracted for the production stage, no medium-term or short-term production planning meetings were held. Four medium-term and short-term design planning meetings were held for discussing and reviewing design changes. In CS3, the decision was made to integrate medium and short-term design plans due to the close interaction between design activities observed in previous studies. In the design meetings, short-term design tasks were established and simultaneously constraints related to performing the design tasks were identified, analysed and listed as tasks for designers.

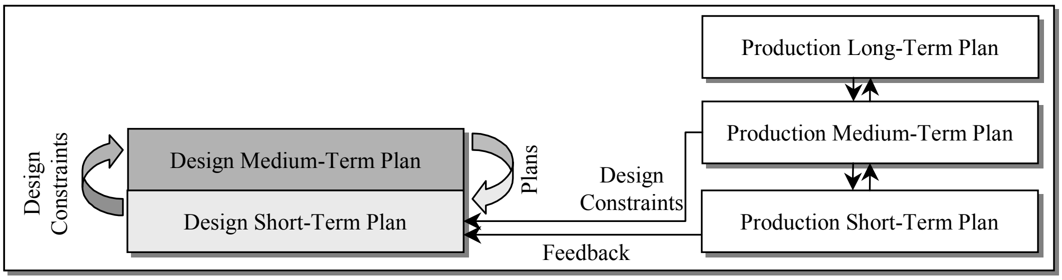

Figure 5 - Planning and control system proposed in CS3

Case Study 4 (CS4)

CS4 involved the execution of two buildings over a 15 month period. The first was a 22,300.00m^2 ten-storey car park building. The second was a 16,450.00m^2 thirteen-storey office building, to accommodate consultation offices, outpatient facilities for different medical specialities, and a cancer care unit. Although the design was completed before the construction company was contracted, it was necessary to make several substantial design changes after the production stage started. The client established a design coordinator to conduct design revisions. Figure 6 illustrates the relationship between design and production planning.

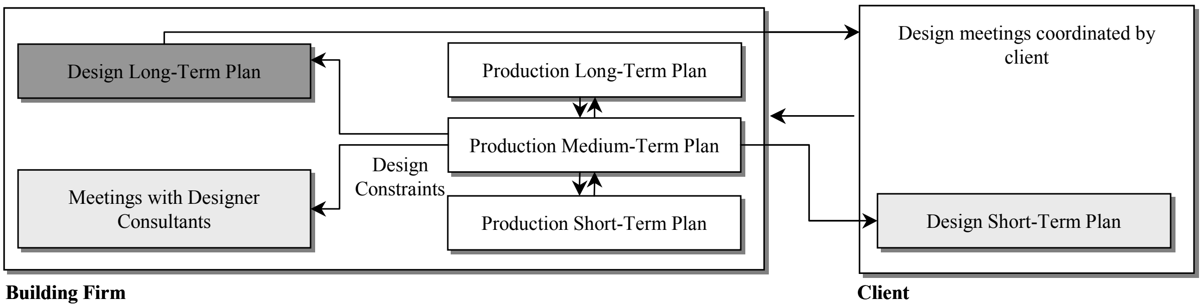

Figure 6 – Relationship between design planning levels for the construction firm and client

In order to avoid delays, the construction manager produced a long-term design plan establishing priorities for the design team. This plan was based on the following decision sequence for each major production process (Figure 7 – read from right to left): (a) the identification of production milestones, (b) the establishment of the lead-time for the supply of the necessary components, as well as the respective managerial activities, and (c) the definition of design milestones.

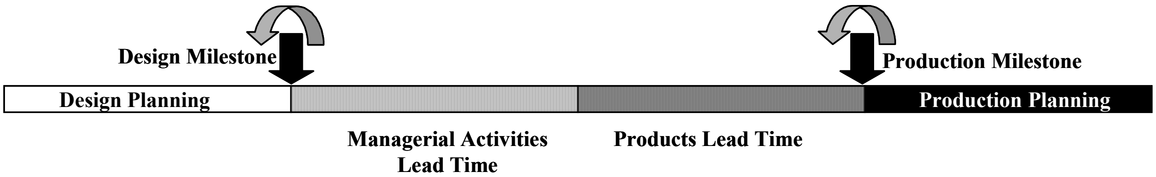

Figure 7 – Criteria for long-term design planning in CS4

Figure 8 represents the spreadsheet developed for the construction company to plan and control the long-term production plan. The designs tasks established on the long-term design plan were broken into smaller tasks by the design coordinator and the designers during weekly design meetings where the construction manager participated. When the time for developing the design tasks was not sufficient, the production manager was consulted about the possibilities to shift the production milestones.

PORTO CONSTRUCTION COMPANY		DESIGN LONG-TERM PLAN				GANTT CHART											
Construction Event	Design tasks	Production milestone (date)	Related lead time (days)	responsible	Design milestone (date)	Jan				Feb				Mar			
						Weeks				Weeks				Weeks			
						1	2	3	4	1	2	3	4	1	2	3	4

Figure 8 – Electronic design long-term planning spreadsheet

RESULTS

The following observations were made concerning the integration of design and production management:

(1) long-term design planning made it possible to identify inconsistent production goals (e.g. in SC4 when the established time was not enough to develop design tasks the production milestones were pushed, generating a more realistic view of the production goals to be achieved);

(2) planning medium-term production planning made it possible to identify constraints related to design[6] and to reduce the number of production non completed tasks due design. Specifically in SC1 21.8% of the causes of the non-completion of the plans were related to design. Most of the problems occurred during the initial three weeks of production when the design was still in development.
(3) short-term design planning made it possible to take into account production requirements in the initial design;
(4) short-term planning and controlling of production made it possible to give feedback from the production to the designers. The causes of non-completion of production tasks were presented to designers in the design meetings;
(5) in SC1, despite the utilization of the Last Planner system for the design and production management, the total concurrency between design and production was not possible. In SC1 the production started four weeks after design had been started. These four weeks were used to improve the design maturity.

Regarding the utilization of the Last Planner System for the design and production management the following observations were made:
(1) the PPC increased as the people involved began to understand the logic of the design and production planning. In SC1, the PPC in design rose from 44% in week 1 to 72% in week 8. In all case studies, the PPC in production increased considerably at the front-end of the production stage;
(2) the involved managers expressed some difficulty in elaborating the short-term design plans and medium-term production plans, however they still considered the results that were obtained satisfactory. The analysis of medium-term production plans and constraints showed that 54% of the tasks were scheduled in week one, 28% in week 2 and 6% on week 3. The rest were related to tasks and constraints identified later and related to the period before week 1 in all cases analyzed;
(3) in projects where design had been considered finished the production manager had difficulties in eliminating design constraints because the design team had been dissolved before the beginning of the production stage;
(4) root causes of non-completion of design tasks were related to the lack of fixed patterns in the information exchange (e.g. different software versions and drawings with a non-established scale);

Finally, in SC1 and SC3 the design was fully developed and delivered on time in the order that was required for production. Although the deadlines were met, in the production phase, however, it was not possible to undertake this analysis, as the data collected bore no relation to meeting the targets.

FINAL CONSIDERATIONS

With the aim of integrating design and production planning and control processes, in this study, we have investigated the possibilities of identifying and defining the information

[6] Constraints related to the design were identified during the whole production stage in all study cases, including those where the design was considered finished. In general, the identified constraints were related to a lack of compatibility between design proposals; unachieved requirements, requested changes in design solutions or to the fact that a specific detailed design had not been done.

requirements for the design in the design and production process. Main contributions are highlighted below:

To completely overlapping the production and design processes was considered inadequate. In this case, the time between the delivery of the design and the start of production must be used to guarantee the maturity of the information made available. The use of small batches of information, recommended by Reinertsen (1997), makes the design process more dynamic. However, planning design activities in small batches of information represents a shift away from the conventional manner in which designers traditionally develop projects (large batches). This may lead to a resistance on the part of designers to use it.

The integration of design planning and control in production management was evidenced through the constraint analysis in the medium-term production planning (where design related production constraints were considered as tasks for designers) and through the analysis of the causes of unfinished work in the short-term production planning. This was also evidenced by the fact that some design solutions were changed to make production deadlines feasible and when production deadlines were changed in the instanced where design tasks demonstrated that the established deadlines were unfeasible. Finally, in terms of design and production planning by adopting the Last Planner System, we have concluded that this is an alternative to the reduction of variability and uncertainty in fast, complex and uncertain construction projects. Similarly to Miles (1998) and Tzortzopoulos et al. (2001), we have observed benefits such as increased efficiency, increased transparency in the design process and increased commitment from the people who are doing the planning. Nevertheless, the use of the Last Planner System for design and production should consider some CE practices such as early team involvement, effective exchange of information and feedback.

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INCLUSIVE DESIGN

USEFUL DESIGN TOOLS? INNOVATION AND EXPERIENCES FROM SUSTAINABLE URBAN MANAGEMENT

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Abstract
Tools for design management are on the agenda in building projects in order to set targets, to choose and prioritise between alternative environmental solutions, to involve stakeholders and to document, evaluate and benchmark. Different types of tools are available, but what can we learn from the use or lack of use of current tools in the development of future design tools for sustainable buildings? Why are some used while others are not? Who is using them? The paper deals with design management, with special focus on sustainable building in Denmark, and the challenge of turning the generally vague and contested concept of sustainability into concrete concepts and building projects. It describes a typology of tools: process tools, impact assessment tools, multi-criteria tools and tools for monitoring. It includes a Danish paradigmatic case study of stakeholder participation in the planning of a new sustainable settlement. The use of design tools is discussed in relation to innovation and stakeholder participation, and it is stressed that the usefulness of design tools is context dependent.

Keywords: Design tools, participation, planning and sustainable buildings.

INTRODUCTION

The increasing demand of documenting the sustainability of a building or a building area causes great attention to ways of working systemically with sustainable design before, during and after a building project is completed. But what is a sustainable building? The authors of this article argue that it is essential to recognize that ’sustainable buildings’ or ‘green buildings’ is a contested notion, open to a number of different interpretations. From case studies of “green buildings” Guy and Osborne (2001) describe 5 competing logics of green buildings and corresponding design strategies:

Green building “logic”	Design strategy
Ecological	Reduce the ecological footprint
Smart	Maximize flexibility
Logic symbolic	Express nature
Comfort	Living building
Community	Create identity

Beside the competing logics the design process of sustainable buildings often involves more complicated decision-making procedures than traditional buildings, and it is no longer a simple process to involve relatively homogenous groups of architects and engineers. Politicians, users, neighbours and different associations are often involved in the planning of a building. Previously, the involvement was often a reaction to a relatively detailed building or urban plan. Today, local actors are often involved at an earlier stage in the design process. They participate in the shaping of visions of a certain location or in formulating specific demands.

The challenge of facilitating dialogue between actors with very different understandings of sustainability is a challenge in most building projects. Where Guy and Osborne focused on the building as result of a design process, Sven Dammann has, in (Dammann 2004), identified four generically different technological frames in his analysis of core actors' understanding of environmental indicators for buildings. The core actors are local building authorities, professional clients, clients, consultants, project designers, administrators of buildings and developers of environmental indicators for buildings. The actors are typically embedded in only one of the technological frames: the public relations, the scientific, the aesthetic-holistic or the layperson-sensualist view. Dammann concludes it is not possible to create *'a common language'* and to agree on one best set of indicators in the near future. People embedded in e.g. an aesthetic-holistic view (mainly architects) have difficulties in understanding people embedded in a natural scientific view (mainly scientific indicator developers and consultants with an engineering background.

The paper deals with design management, with special focus on sustainable building in Denmark, and the challenge of turning the generally vague and contested concept of sustainability into concrete concepts and building projects. We here use the term design management broadly as a discipline relating to all building processes regarding the overall concept of a building, to the processes of detailing building parts and future use of the building. While doing so we will primarily focus on the process of establishing such concepts, and discuss the roles of the different actors involved, and especially pay attention to the role of a new type of design managers having the role as process-facilitators or "intermediaries" between project stakeholders. The content of the paper is:

- Firstly, we address the need for tools for sustainable urban management, and based on theories of Ecological Modernisation (EM) we point to the emergence of new intermediaries in the house building.
- Secondly, we outline some of the different types of tools available for sustainable design management. Through an overview/ typology of these tools we discuss how the roles for "traditional" experts and design managers have changed, and describe the virtues of the "new" facilitators in design management in contrast to "traditional" management.
- Thirdly, we are going to present a case of sustainable design management from Denmark, the Teglmose site in the municipality of Albertslund. We are going to illustrate how the process of involving different types of stakeholders in the design, including the management of different concepts and views, was the core of the sustainable design process in this case study. Based on theories of EM we intend to argue that such roles and functions of intermediate actors will increasingly become important in facilitating sustainable building design. Also, we are going to discuss the problems and barriers related to such processes, and to the methodology used in the case.
- The conclusion stresses the need for design managers with the ability of using tools and involving stakeholders in the early phases of a building project in order to develop and identify stakeholder values as guidance in the design of a specific sustainable building.

THEORETICAL FRAME: ECOLOGICAL MODERNISATION AND BUILDING DESIGN

We focus on three distinct features of Ecological Modernisation (EM): Firstly, that the EM approach in general is oriented towards self-regulation, collaboration and consultation with those to be regulated (Mol et al. 2000; Boström 2003). Secondly, Boström also emphasises that new intermediary actors are involved in facilitating the participatory strategies (ibid.:176f). Finally, that EM implies the use of a series of different tools to support the design process - not only to measure and assess the environment, but also to manage the participatory processes.

When the first 'green' buildings were constructed in Denmark in the 1970s they were radically different from conventional building design, and they were seen as a protest against conventional buildings. Today, sustainability develops in more directions – one line is the integration of elements, such as resource saving in regulation and hence mainstream buildings. This is followed by the development of a number of tools, e.g. Manual for Environmental Management of Project Design, Green Accounting, Environmental Declaration of Buildings, Green Diploma and others. Moreover, we see local actors develop their own systems and methods to incorporate sustainability in their daily routines, especially in the non-profit housing sector.

Many such tools include what Boström has called "voluntary rules". Actors in the field of sustainable building increasingly develop directives, norms or standards, to fill in the vacuum emerging from the absence of the state, as well as demands for environmental protection. As the state withdraws, there is an increasing number of voluntary rules emerging from private and public actors (Boström, 2003). Such voluntary rules can be seen as examples of sub-politics (Beck, 1992), but in practice these are often new ways of state regulation; usually financed by the state or by the EU. Based on the research project PETUS (Practical Evaluation Tools for Urban Sustainability, http://www.petus.eu.com/), financed by the 5th Framework Programme under the EU) we are later going to outline some of the different types of tools available for sustainable design management.

A central question raised in relation to the ecological crisis is whether the institutions, that created the environmental problems, also are able to solve them (Beck 1992). The designers of the first generation of sustainable housing in Denmark would argue that this is not possible, and they would see innovation as something happening outside the established institutions. Representatives of Ecological Modernisation (EM) present an optimistic view on this: Institutions are able to renew themselves and to integrate environmental issues in existing policies. Instead of seeing environmental challenges as barriers they become locomotives for innovation; instead of seeing environmental challenges as anti-modernist and anti-growth they are seen as a win-win game (Hajer 1995). EM implies new institutional arrangements in which the authorities' collaboration with other actors is central, as a contrast to traditional politics where changes are sought through legal regulation (Boström 2003:176). Hence in the building sector inclusive and interactive forms of policy- making is used to integrate environment solutions and voluntary rulemaking or standardisation. This feature also calls attention to the involvement of end users in the design processes. Therefore we see housing associations and private house owners being increasingly involved in designing their own houses. This is also made possible because of a current 'unbundling' (Graham and Marvin 2001) of infrastructure systems and innovation of small technologies, which e.g. make it possible to design your own individual energy supply or waste water treatment.

In the processes of restructuring cities and their infrastructure systems, new types of actors act in-between the traditional relationships between utilities, regulators and users in order to enable the uptake of new technologies and social practices (Moss and Wissen 2005). In the process of developing practices of sustainable urban management in Denmark, NGOs like the Local Energy and Environment Centres are seen as key actors in order to raise awareness of environmental problems, to promote sustainable solutions and as intermediaries between representatives of the urban systems and the citizens. Intermediaries are organisations that act in-between the traditional relationships between utilities, regulators and consumers in order to enable the uptake of new technologies and changed social practices within the production-consumption relationship to reshape the intensity, timing and level of resource use (Moss and Wissen 2005). Boström (2003) and others emphasize the environmental organisations that since the 60s have been very active introducing environmental issues: As opponents to the established system neglecting problems, such as the pollution of the water environment (Læssøe & Jamison 1990, Boström 2003), the NGOs contributed to develop the environmental discourse that EM now embodies. Today, the distance between authorities/public institutions and other actors, including green NGO's, has diminished; environmental organizations are generally not seen as opponents to public institutions. However, the NGOs often maintain a role as challengers to the established system in order to push development further. Not least in the building sector this group of actors has had a large influence on the introduction of the notion 'urban ecology' and the continuous experiments with small-scale technology. They have a large share in technologies such as solar panels and water saving toilets, which 15 years ago seemed to be ridiculous to many, but which now are mainstream. However, also organisations such as housing associations have been part of this development as they have joined the experiments enabling large-scale implementations.

An important feature of EM is to make environmental issues calculable. EM focuses on how flows of matter and energy could be better managed and controlled by integrating both technical and social aspects. During the integration of environmental values into the institutions, the environment is transformed into manageable entities such as measurable goals, quotas, norms and green taxes also serving marked purposes (Van Tatenhove & Leroy 2003; Elle et al. 2003). This is reflected in the building sector, e.g. in the building regulations as well as in the way flows of water and energy are monitored: meters make these flows visible to the users. For building design ecological modernisation implies new institutional arrangements and a need to work explicit with sustainability. Like the four technological frames identified by Dammann, ecological modernisation belongs mainly to the scientific frame.

TYPOLOGY OF DESIGN TOOLS

Since there are contested perceptions of a sustainable building project, design managers have to make several decisions in the design of a sustainable building project. The search for design tools are often motivated by the following questions:

- How to assess and prioritize between environmental solutions? The choice needs to be clear and validated so it can be presented to others.
- What are the project targets and how do they relate to best practice? Clarifications of visions and project targets are important to decide if the project needs conventional or innovative solutions.
- Involvement of relevant stakeholders? Is this a part of the project or not? Who are the stakeholders and how do they participate?
- How to document sustainability throughout the lifetime of the building?
- Evaluation, what is needed? In order to evaluate the design process decisions documentation is needed for the performance of the building in operations

In the research project PETUS (Practical Evaluation Tools for Urban Sustainability) a group of European researchers and practitioners investigate the current use of tools. The tools relate to different stages in a decision-making process related to a sustainable building project:

Monitoring	Tools for monitoring the building in the operation phase. This includes tools for environmental accounting (for instance the Danish “Green Accounting for buildings”) and more general Environmental Management Systems (EMS), such as “The Green Diploma for buildings”. In principle these aim to include the users of the building in a continuous effort to monitor flows. Therefore such tools need to be operational for non-experts and not require too much data-input.
Calculation and forecasting	Tools for calculating and forecasting the environmental consequences of different alternatives, for instance the LCA-tool BEAT for buildings and products. This group also includes other approaches to sustainability than the ?, for instance the Ecological Footprint, Ecological Rucksack, Environmental Space and Sustainability Gaps are all based on other principles for environmental assessments, as well as it includes tools for calculating social and economic consequences of different alternatives.
Valuation	Tools for weighting different aspects; not only environmental, social and economic, but also different environmental aspects (for instance, should water saving toilets have a higher priority than PV’s?). Examples are Multi-Criteria Assessment methods, valuation grids and others.
Process	Tools to guide the process of sustainable projects and planning; for instance the different steps to include, and which sub-tools to use on the different steps. This might include methods of how to involve the right stakeholders, how to prioritize between different alternatives, how to define a baseline, goals, and indicators for monitoring. One Danish example is the Manual for Environmental Management of Project Design, MEMPD, and on a more general scale, Strategic Environmental Planning (SEA).

Monitoring tools are primarily used in existing buildings. Here, sustainability includes technology and behaviour of the local actors – the residents, the caretakers, the local housing department and others. The tools are often used and implemented by intermediary actors such as local housing departments or local green guides. However, monitoring tools can also be used for post-evaluation of a sustainable building project (such as in the Hedebygade Urban Ecology Renewal in Copenhagen).

Calculation tools represent a more "traditional" expert approach to sustainability; here, the environmental impacts of different alternatives are calculated with a tool, which will provide a result that cannot often be discussed. If a LCA tool is used, the most sustainable building is the one with the lowest emissions over a lifetime. This approach relies on the assumption that knowledge will guide you to the best result; if the client knows the alternative with the lowest emissions, he/she will automatically choose this. However, the tools are built on assumptions most often contested.

Valuation tools are based on bringing forward the values from the involved actors before choosing a design. Often it is based on inputs from calculation tools, but this must be seen in relation to all aspects of sustainability (environmental, social and economic).

Process tools describe which steps to include in the process of designing a sustainable building, and suggest which sub-tools to use in different steps of the process. Sustainability is defined by the process and by the client himself; the expert is just one voice to be heard amongst the choir of stakeholders (owner, designer, user, authority, utilities etc.). Process tools can be very extensive, as they prescribe all the fundamentally correct steps and procedures to be included in a process of sustainable building design. Following all these steps and using all these sub-tools can be rather demanding. This is a frequently raised critique against the main process tool for sustainable building in Denmark, MEMPD, and probably a main reason why it is only marginally used. The ABC planner, which is the successor to MEMPD, has aimed at simplifying the procedures and making the tool easier to use). In practice we often see tools used in an adapted form, where some procedures are included and others are left out.

From the research carried out in PETUS we find, that in many of the cases where a tool is being used, it is the developer of the tools who is using it in the role as an "expert" or a "facilitator". The developers of the tools include researchers, consultants, NGOs and collaborations between main actors in the sector. Developers of such tools fulfil the role of providing methodologies and tools to incorporate sustainability in new and existing buildings. The problems and barriers related to the use of design tools were identified as:

- lack of knowledge about the tool
- the tool is too complicated and demands too many resources (time and qualifications)
- the tools is too abstract or too case-oriented
- the tool lacks legality, reliability and clarity
- the necessary data are non existent or not easily available

The experience of using tools is to some extent dependent on the expectations of the tool and to the user's experience of the need for it. It is likely that design managers belonging to a scientific technological frame find it more useful to spend time and resources of e.g.

creating data for a LCA than a design manager belonging to the aesthetic-holistic frame does. In the last part of the paper we are going to focus on process tools, because we see multi-stakeholder design processes as a new direction in design management and we find that process tools are necessary for professional design management.

A PARADIGM FOR CITIZENS' PARTICIPATION: THE TEGLMOSE PROCESS

In the following we shall present a paradigm for establishing a dialogue between stakeholders in the planning of the settlement in order to formulate a building program. The paradigm is based on the case of the Tegelmose Site in Albertslund in 2000-2001.

Before planning a new public housing area with approximately 100 dwellings in the municipality of Albertslund in Denmark, the politicians decided to initiate a planning process with an ambitious vision of sustainable housing, concrete goals of performance and stakeholders' involvement. Three tools were used in the Teglmose process: A context analysis in terms of physical, social, technical and environmental conditions at the building site and its surroundings. The context analysis enables a systematic integration of context in the planning process. A multi criteria analysis was made to assess a broad selection of sustainable technologies on the basis of the locality analysis. With the multi criteria screening different technological solutions were assessed according to the environmental impact, economy, technology, comfort, self-management, robustness and demonstration value. The assessment was made on a relative scale with the conventional standard solution as reference. Thirdly, a dialogue workshop was organised for local key persons (citizens) to create visions and set goals for the housing area. A side effect of the process was the establishment of an association of future residents with the objective to build on the site.

Electricity production	Environ mental impact	Eco-nomy	Tech-nology	Comfort	Self-ma-nagemen t	Robust-ness	Demo value	Priority
CO_2 neutral windmills	++	++	+	0	0	++	+	1/++
CO_2 neutral PV´s	+	-	+ (new)	0	0	++	++	/+

Illustration of multi criteria screening of technology (http://www.petus.eu.com/images/Denmark.pdf)

The process of the Teglmose site has been ideal in terms of the ambitious political vision and the willingness to invest in stakeholder participation in the decision process. It should be said that at this point the project is not realised, therefore it is not possible to evaluate the actual performance of the suggested housing area. From our point of view the Teglmose process serves to be used as paradigm for other similar building projects for several reasons. Firstly, because it works systematically with the integration of context and analysis of possible environmental solutions. Secondly, it creates a forum for discussion among stakeholders on values in building design. Thirdly, the different stakeholder groups' involvement in the process matches their competences, as they formulate the basic values of the future settlement instead of them making technical choices. A key issue for the success of the Teglmose site was the use of external assistance to play the intermediary role. The external partner had the technical and scientific insight in the multi-criteria tool and was able to facilitate the dialogue. This combination is most useful, and in our opinion both skills are necessary for a professional use of design tools.

CONCLUSION

Transformation of contested understandings of sustainable buildings to a context specific concept is identified as a core challenge to design managers. In order to do so the design managers need to have a holistic understanding of the building project and to be able to handle a design process in dialogue with stakeholders with very different understandings of the future building. The paper points to the use of tools for different purposes in the design process, and it promotes experiences from sustainable urban management. In this field innovation of sustainable buildings is facilitated by new intermediary actors, and therefore an innovation strategy is to open the design process to a broader group of stakeholders. Future design managers must be able to facilitate the process of identifying project values and structure the design process according to these values.

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ARCHITECTURE AND PEOPLE – the relationship between sociopsychological and urban aspects

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Abstract
The main goal of this paper is to awaken the consciousness about the importance of people's wishes, desires and expectations during the process of designing, investing or living. The living environment, living places, working places, buildings, infrastructure, green places surround people all the time; therefore real estates are one of the most important elements of everyday life. The problem generally refers to the relationship between sociopsychological and other aspects (functional, economic, normative, and technical) of real estate. More concretely, we were interested in the following question: which is the structure of perceptions connected with different aspects of real estate in the living place and in its environment? Target groups were employees of real estate agencies, people, employed in important public institutions and students of psychology from Slovenia. We applied the questionnaire, containing questions about subjective and objective characteristics of real estates and correspondent's perceptions. We made multidimensional scaling of perceptions of the: ideal / non-ideal living or working place, serious environmental problems, place of living and people living there.

Keywords: living environment, living places, perceptions of real estates, working places.

SOCIOPSYCHOLOGICAL ASPECTS OF REAL ESTATE

The relation towards real estate can be seen on every field of human life, what is dependent from social clime, self-evaluation, value, life-style, culture, identity and efficiency of individuals. How are these relations mixed together, how individuals experience them, what are their influence on everyday life, residence, activities, all these are questions which should interest architects while planning surroundings, buildings, dwelling and working units; and also investors from the standpoint of creating desirable and pleasurable investments.

The human relationship with nature can't be seen only through technical progress, development, knowledge, this relationship depends also with the notion of value. The whole of mankind, what it means, every society and culture in a specific way, is constantly in the phase of a value transformation (Rus, 1997). What is essential for values is that they are relatively stable, what represents permanent disposition of the individual and permanent characteristics of social orientations and representation elements, which could be changed in some specific cases. This can happen when the whole value system is changed under the influence of social ageneses. The fact that 'values are in people and not in objects' tells us that objects are the subjects of value only when they are desirable for the people. Schwartz (1990) defined values as trans-situational, instrumental and terminal goals, which express individual, social (or both) interests linked with different type of motivation.

Physical characteristics influence the social behaviour in specific areas, for example: size, disposition, sonority, colours, age, height, view, side, access, nearness of the markets and services, largeness, furniture, warming, humidity, technologies, status of the neighbourhood and others.

One important question of the psychological studies is the interaction between the individual and the environment, it means between the individual and its immediate physical environment, to be more exact, with some of its components. Piaget (1965) introduced this interaction with the model of assimilation and accommodation. The word interaction means interrelation activity or influence of the surroundings on the individual and the opposite. The models of the interaction between a human and the environment (Rus, 1997) refer to social variables analyses (individual and group, personality, culture, parts, organizations, social-economic characteristics) considering the influence of physical factors and variable analyses of the physical and formed environment (architecture and landscape characteristics, process characteristics, dimension and frequencies of different events in environment).

Architectural determinism is one of the modern techniques of social control of an environment. Residential and working places are shaped and built so that a model of social communication and relation to the physical environment is defined. Someone who lives in town, doesn't perceive town like a picture, the perception is organized with the practical and affective functions of life, which links them together (Choey, 1965, Rihtar 1999).

PROBLEM

The given problem is an importance of social and value orientation, a perception of life style and national stereotypes, which appear at the beginning, during the preservation and a change of social perceptions with references to the space, environment and real estates. We can hypothetically foresee, that different perceptions of residential place, it's surrounding, place of living, working place and organization and geographical real estate problems of environment are connected with the different social and value orientations.

The questionnaire is used as an instrument, which captures variables through the field of demographic, social-culture, socio-economic status on a social environment, in which the real estate can be found. The standpoints and social knowledge in connection with real estate, social clime, culture, leadership, values, communications, as indication of organization function efficiency and relationship toward real estate in Slovenia and Europe are captured.

Three different target groups of participants were embraced in the research: 1/ students of psychology from Ljubljana University, Slovenia (n = 25, mean age = 25.80, share of 0.1 men participants); 2/ owners or employees of real estate agencies in Slovenia (n = 31, mean age = 43.55, share of 0.6 men participants); 3/ employees in the public sector and state institutions from Slovenia (n=24, mean age = 39.2, share of 0.4 men participants).

RESULTS OF SOCIAL PERCEPTIONS IN CONNECTIONS WITH SPACE, ENVIRONMENT AND REAL ESTATE

Comparison of results – ideal / non-ideal working place

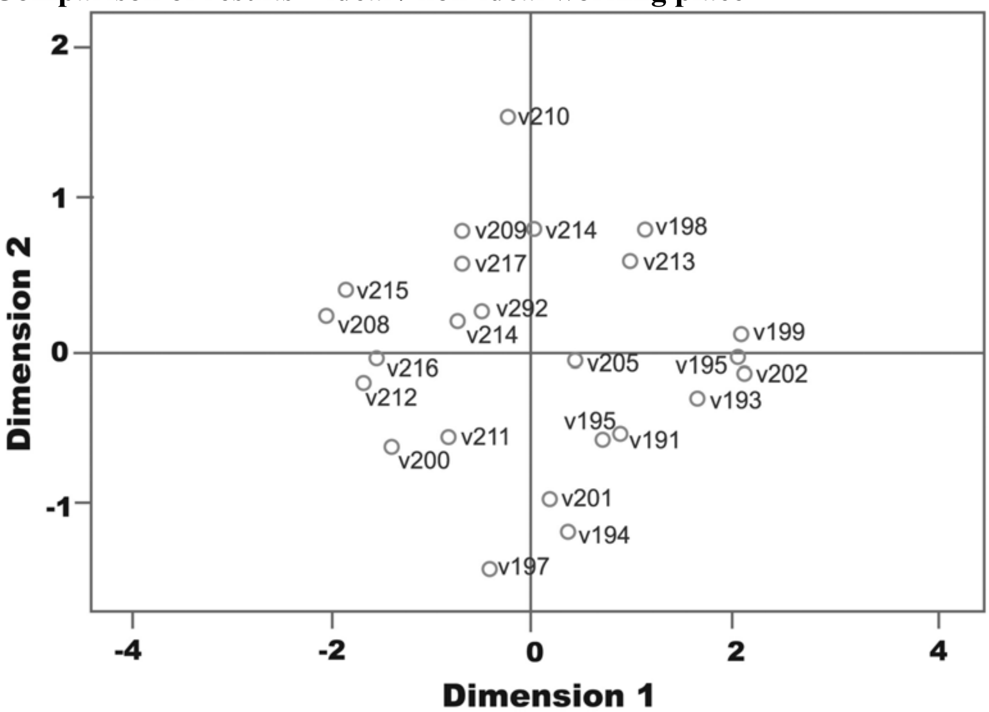

Table 1 – Euclidian distance model of ideal or non-ideal working place

Note: 'IDEAL PLACE': v191- on lower floors, v192 – on higher floors, v193 – made from new materials, v194 – with wood finishing, v195 – with big windows, v196 – private ownership, v197 – in house, v198 – in office buildings, v199 – in town, v200 – in village, v201 – near city bypasses, v202 – with modern design, 'NON-IDEAL PLACE': v204 - on low floors, v205 – on high floors, v206 – made from new materials, v207 – with wood finishing, v208 – with big windows, v209 – private ownership, v210 – in house, v211 – in office buildings, v212 – in town, v213 – in village, v214 – near city bypasses, v215 – with modern design;

Numerous = 50, Stress = 0.16, RSQ = 0.87.

Looking at the results we can see central arrange of results. On the left are mostly results connecting with a non-ideal place, on the right there are in connection with an ideal place. There are three independent results: an ideal place in the house (v197), a non-ideal place in the house (v210) and non-ideal place on the high floors (v205).

We can find out from table 1 that two principals of desirable working places have appeared: in urban space, in buildings with modern architecture, with big windows and on the other side: in the villages or near city bypasses, in private ownership, on the lower floors, with wood finishing. Different installation of working places are also dependent of working processes or activities: the confused traffic, the lack of the parking places, inefficient public transport, high concentration of public services, offices are typically for the urban space. Chuen (1996) said that high buildings block views, cut the stream of sunrays and air, which causes the value to decrease. He claimed that the feeling is the same as staying in front of a high mountain. On the other hand the high buildings represent a symbol of social, economic power, reputation and progress of civilisation or state (Barnard, Correa, Moser, 1987). Even the communication with other offices, institutions, services is very important – the optimisation of time, connected with everyday function is very important of a modern business rhythm.

Comparison of results – ideal / non-ideal residential place

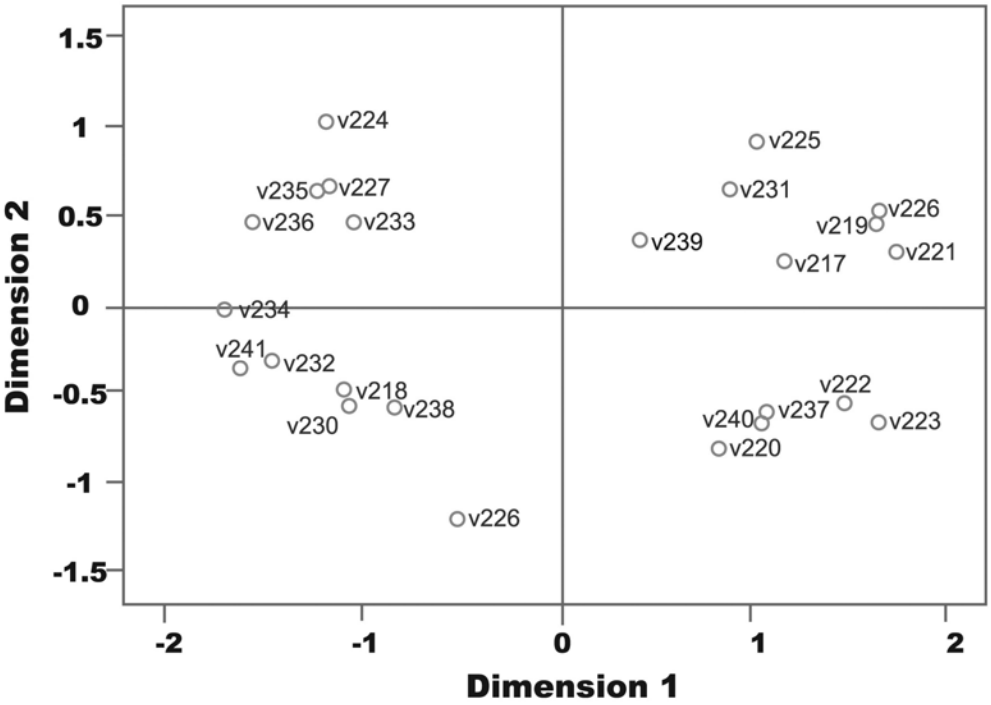

Table 2 – Euclidian distance model of ideal or non-ideal residential place

Note: 'IDEAL PLACE': v217- on lower floors, v218 – on higher floors, v219 – made from new materials, v220 – with wood finishing, v221 – with big windows, v222 – private ownership, v223 – in house, v224 – in office buildings, v225 – in town, v226 – in village, v227– near city bypasses, v228 – with modern design, 'NON-IDEAL PLACE': v230 - on low floors, v231 – on high floors, v232 – made from new materials, v233 – with wood finishing, v234 – with big windows, v235 – private ownership, v236 – in house, v237 – in office buildings, v238 – in town, v239 – in village, v 240 – near city bypasses, v241 – with modern design.

Numerous = 48, Stress = 0.12, RSQ = 0.94

The results are arranged at four quadrants. The non-ideal characteristics of a residential place are on the left side and the ideal ones are on the right side. Almost all of the results are in groups; only the answers connected with ideal place in a village (v226) and in a business building (v224) and a non-ideal place in a village (v239) are independent.

We can see, when the perception of an ideal residential place is connected with characteristic near the city bypasses, the perception of a non-ideal place is connected with the characteristics: with wood finishing, in private ownership and in the house (v227, v 233, v235, v236) and the opposite (v220, v222, v223, v237, v240). It is similar looking to the perception of choosing an ideal place on the lower floors, built of modern materials, with big windows, with a modern design (v217, v219, v221, v228), and when the perception for the ideal place is on the higher floors, then the non-ideal characteristics are: on the lower floors and in town (v218, v230, v238).

The dreams of residents of developed countries are dwelling in houses within a green and intact environment near towns, working in towns (Pogačnik, 1986). The urban – architecture designs nowadays in Slovenia are a mixed settlement of residential buildings and individual buildings, houses in rows, business buildings with houses on the roofs on the outskirt of town. Dominigue Lassare (1986) researched the need for private ownership in her work 'To have a house or real estate property or to hire it'. Research has shown that there were different relationships towards real estate depending on the ownership of the respondents. The owners of the real estate invested in the houses much more than renters in an economical and a psychological way. They reduced leisure time activities for the purpose of managing high costs; at the same time they regarded their homes like a prime leisure time activity. The selected life style followed the chosen sample for having its own home. Owners choose their homes much more carefully than renters. Passing over from a renting to an ownership term was the way to achieve the wish to build their home.

Comparison of results – serious problems with the land

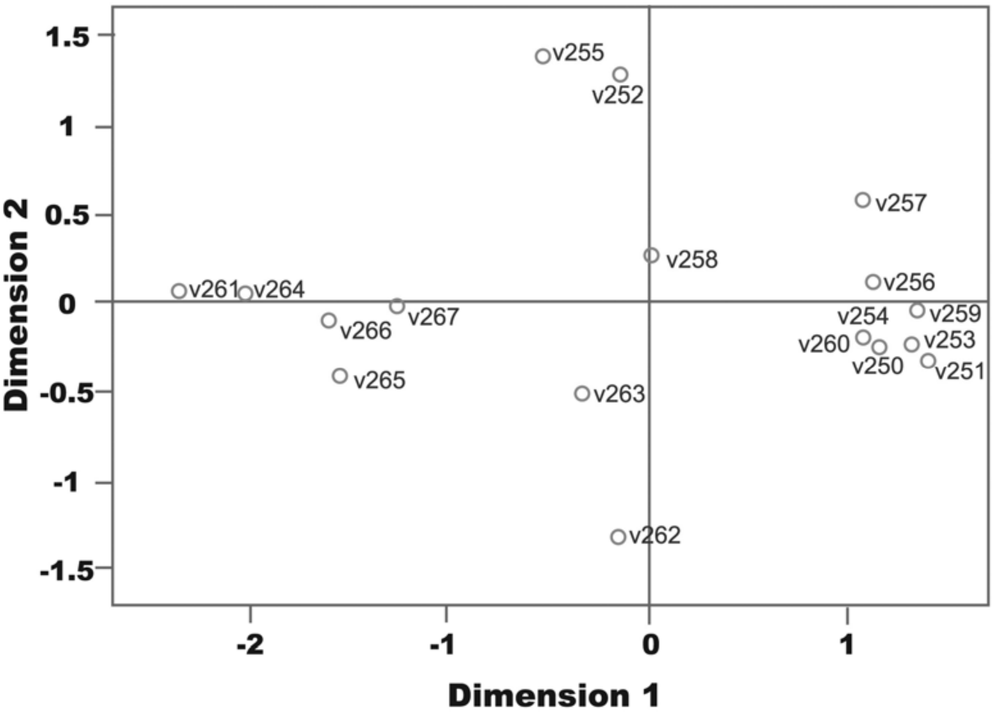

Table 3 – Euclidian distance model of perceptions of serious problems connected with land

Note: 'IN SLOVENIA': v250 – water pollution, v251 – pollution of underground water, v252 – unsolved denationalisation problems, v253 – uncontrolled rubbish dumping, v254 – urban planning, v255 – selling real estates to foreigners, v256 – land register problems, v257 – unsuitable loan politics, v258 – professionalism of real estate agencies, 'IN EUROPE': v259 – water pollution, v260 – pollution of underground water, v261 – unsolved denationalisation problems, v262 – uncontrolled rubbish dumping, v263 – urban planning, v264 – selling real estates to foreigners, v265 – land register problems, v266 – unsuitable loan politics, v267 – professionalism of the real estate agencies.

Numerous = 74, Stress = 0.08, RSQ = 0.97

Results are concentrated around a horizontal axel – left and right; some independent results are around a vertical axis. On the right side there are results connected with the environmental problems and on the left with the real estate policies. The independent ones have answers connected with: unsolved denationalisation problems in Slovenia (v252), selling real estates to foreigners (v255), professionalism of real estate agencies in Slovenia (v258), unsuitable loan politics in Slovenia (v257), urban planning in Europe (v263) and uncontrolled rubbish dumping (v262) in Europe.

Unsolved denationalisation problems, selling real estates to foreigners, land register problems, unsuitable loan politics, and the professionalism of real estate agencies are themes that concern Slovenian politics since the time of independence. In the meantime a lot of legislation changes were accepted, for example: obligatory real estate licenses for real estate agents, residential legislation and land register legislation, informationization of land and buildings registrations, there are more possibilities for taking a loan for residential purposes. Dušan Plut gave a warning on dilemmas concerning the National Program of an environmental protection between the development strategy and environmental problems. He was asking himself how to harmonize the increase of a national production and environmental demands, how to stop the increase of energy intensity, how to ensure the exploitation of alternative energy opportunities and not to ruin the values of nature (Ogorelec, 2004). With the care taking effect, sustainable urban planning in Slovenia try to avoid these problems, what it means to sustain interventions into the natural environment in such a way that construction (in the mean of location and technology) is set in a natural environment with minimum influences.

Comparison of results – opinion about the place of living and people living there

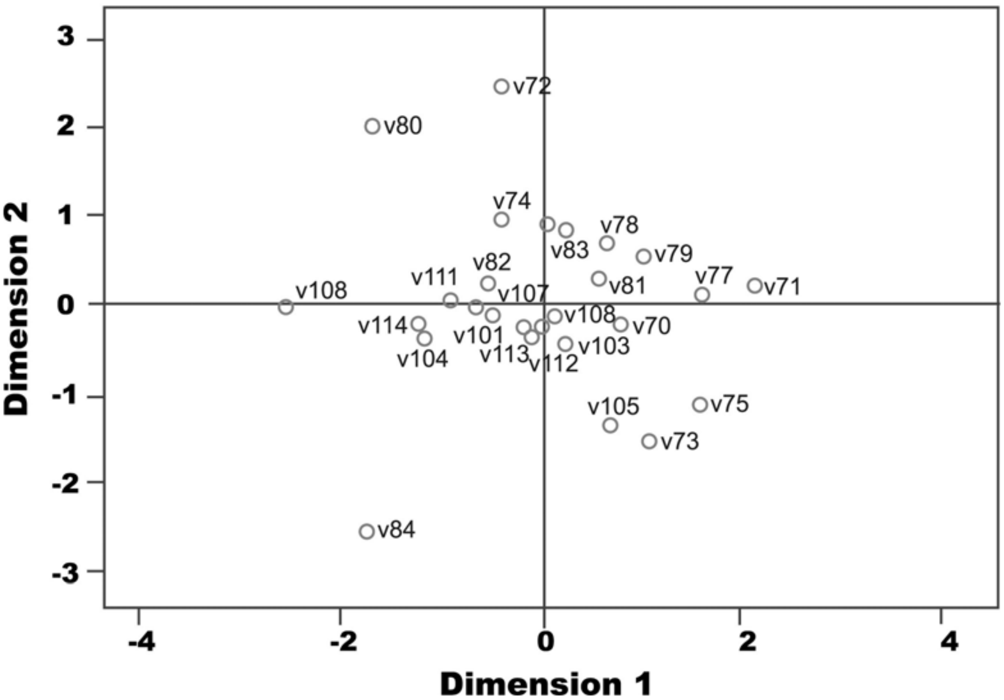

Table 4 - Euclidian distance model of opinion about the place of living and people, living there

Note: 'PLACE OF LIVING': v70 – clean or dirty, v71 – supplied or not, v72 – cultural interesting or not, v73 – tranquil or noisy, v74 – amusing or bored, v75 – peaceful or violent, v76 – friendly or hostile, v77 – kindly or not, v78 – social or not, v79 – opened or closed, v80 – lives with truism or not, v81 – blooming or not, v82 – with good management or not, v83 – with good offer or not, v84 – dynamic or not, v85 – collaborate with local peoples or not, 'PEOPLE LIVING THERE': v101 – optimistic or pessimistic, v102 – active or passive, v103 – independent from the others or not, v 104 – worth copying or not, v105 – calm or not, v106 – oriented on future or past, v107 – interesting or monotone, v108 – focus on everyday or not, v109 – in harmony with oneself or not, v110 – successful or not, v111 – opened or closed, v112 – prudential or not, v113 – convinced in ones own aims or not, v114 – oriented inward / outward.

Numerous = 84,   Stress = 0.17,   RSQ = 0.88

The results are centrally oriented, only some independent characteristics are oriented from outside, for example: cultural characteristics of a place (v72), (v80), dynamic characteristic of a place (v84), focus on everyday life (v108) and a group of three characteristics: the perception if the place is tranquil or noisy (v73), peaceful or violent (v75) and if the people there are calm or exciting.

The urban offer of the place is important to the people who live there: everyday life surroundings, a breathable space, which has beside a built environment enough space for a promenade, rest, recreation, which has parks, wide streets, squares, coffee houses with terraces, a place where everyone can calmly go for a walk, seat, associate with. People need nature, so in the urban environment are more desirable parks, green places and promenades (Davidson, 1999). Towns, which consider this orientation of its citizens, are greener, more open space, with more humane areas, so that the open space can be felt also in the dwelling places, as a better feeling of residence. In developed countries there are trends in the way of decreasing numbers of citizens of huge towns, and an increase in smaller towns and outskirts. Citizens of these green peripheries have more choices of working places, education, shopping or culture in one or another urban centre. The urban designers are thinking nowadays about periphery centres, polycentrism and organized dispersion. The great mobility, an atomisation of the family, an appearance of big commercial centres, all of these marks spatial patterns nowadays (Pogačnik, 1986).

DISCUSSION

The problem of this research was viewed on different levels, starting from the point that the real estate problems are inseparably connected with the problems with the physical and the social environment, infrastructure, health, urbanism, architecture and sociopsychological aspects, connected with different real estate characteristics.

In the individual perception of the environment we can talk about the perception of places, which perform totality with the environment in which someone lives, works or in which is active in a different way. Every environment, which surrounds humans, has some specialties, characteristics, on which we put some special attention, because these are important for humans, his life, existence, dwelling, leisure time and work.

Also the wide physics, social environment is important, which represents the national place of living, state or relatively concluded macro culture. It goes for the perceptions of similarity and differences between Europe and Slovenia considering its natural and cultural heritage, perception of important problems, appearing with the land, constructing, and the perception of similarity with Europe, connected with problems of real estate, proprietary and ecology problems.

The use value of designed residential capacities fairly depends on veneration of human preferences within the matter of living place and in its environment. Therefore we can establish that such an analysis which is shown in the paper, suitably extended to all relevant questionnaire items, represents an important subjective input of basic programme definitions in spatial disposition, building comprise, shape, type, purpose, and land use.

It becomes obvious that whenever we strike on the lack of objective performances, generally accepted as standards and guidelines in urban development process, we can always involve the subjective results of such an analysis. For the "use value" of residential build-up development is individually, regionally and chronologically dependent we see this checking process permanent.

The target utilization of the analysis results can be directed into proper urban documentation supply, within the legislation area, or towards architectural environment and technical project documentation, concerning the built-realization phase. Furthermore we suggest that calibrated results of adequately extended analysis need to become parallel terms of investors' references, concerning urban planning and development and architectural design.

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PHYSICAL ACCESSIBILITY ON CAMPUS: EVALUATING THE PRINCIPLES OF UNIVERSAL DESIGN

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Abstract
The principles of Universal Design (UD) must be basic architectural design considerations today. Schools of Architecture throughout the world have made an effort to incorporate these concerns into their curriculi. University campi, on the other hand, and schools of Architecture as buildings do not fully incorporate these principles and many physical accessibility problems persist. In Brazil legislation, obliging the design of the built environment to be inclusive, was devised in 1993. This legislation however has not been fully enforced and public university campi have made few efforts to bring about building and urban design transformations. This paper describes the efforts planned by the University of Campinas to come to terms with the problems of accessibility. Difficulties in funding building programs to adjust the existing environments to the UD principles are presented. Strategies for Universal Design Evaluation (UDE) are outlined. Curriculum changes for both the Civil Engineering and Architecture Courses are described and methods to increase environmental accessibility consciousness are discussed. Teaching methods to increase environmental awareness have been tested as part of design methods. Students work is evaluated, especially the final graduating design projects to assess the inclusion of UD principles as a creative design stimulus.

Keywords: Design Teaching Methods, Environmental Awareness, University Campi, Universal Design.

INTRODUCTION

The principles and application of Universal Design (UD) in the built environment are fundamental requirements for the development of human life both in public or private space. To improve the quality of mobility of a person and increase his or her social inclusion are challenges as well as obligations, especially for institutions. There are many barriers present in the built environment which can hamper the activities of a population and especially, but at times unnecessarily, individuals with some disability. Thus these individuals may suffer some kind of disadvantage which could be overcome by better designed spaces, indoor or out. According to Brazilian statistics 14,5% of the population suffers some kind of architectural barriers, which compromise access to homes, streets, transportations means, urban furniture, schools, etc. (Revista do Terceiro Setor, 2005). To overcome such obstacles is the primary goal of Universal Design and its concept of architectural design without barriers. Universal Design can be described as the design of products, spaces and communication elements to be used by all people under equal conditions. UD is also called inclusive design, design-for-all and human cantered design.

The history of Universal Design has its beginning in the 1950s when new and special attention is given to design for people with disabilities. In Europe, Japan and the USA barrier-free designs were being introduced to remove obstacles in the built environment

(STORY et al, 1998). In the 1990s, Ron Mace led a group of designers and advocates of such ideas and created the seven principles of Universal Design. These are: Equitable use; Flexibility in use; Intuitive use; Perceptible information; Tolerance for error; Low physical effort; Size and space for approach and use (STORY, 2001). In the USA these principles were adopted for accessibility programs and rules were created as found in the "Americans with Disabilities Act". The principal aim of the Act is to offer equal opportunities for all people, especially with regard to the built environment (Adaptive Environments Center Inc, 1995).

Once these principles were established, a new posture with regard to design was expected to improve environmental quality of buildings and urban spaces. Concerns are human comfort and accessibility that an environment offers to users. In Brazil, these principles and rules have been adopted as well and incorporated in local ordinances (NBR 9050, 2004).

The campus of a University and its building stock represent a city environment with similar conditions found in many urban areas. Many campi around the world are acting on their accessibility conditions to provide a better environment for all students. The University of Ontario, Canada, can be used as a good example in its efforts to improve the quality of its campus through specific strategies (DCAAT & UOIT, 2003).
Some public high education institutions in Brazil have also made efforts to transform their campi into inclusive environments on a wider basis, including educational programs, introduction of specialized equipments and signs, as well as availability of reading material for the visually impaired. The University of Campinas, UNICAMP, has an inclusive educational program called "Programa da Proesp/Mec" (MANTOAN e BARANAUSKAS, 2003) and the University of São Paulo, USP, is active through its "Programa Usp-Legal". The Federal University of Espírito Santo, UFES, also developed a similar program to the one found in USP (PEIXOTO, 2005) and the Federal University of Rio de Janeiro, UFRJ, has a research group with a project called "Núcleo Pró-Acesso" (DUARTE e COHEN, 2004). The University of the Itajaí Valley, (Universidade do Vale de Itajaí) in the State of Santa Catarina, developed a study to increase the accessibility conditions on its campus (BINS ELY et al., 2004).

The UNICAMP program is based on the identification of accessibility problems on the campus, the necessary actions to restore accessibility through the removal of architectural barriers and the introduction of a better physical infra-structure for the university. The necessary interventions will be analyzed and implemented in at least one faculty. The university buildings performance will be assessed and the human perception and public satisfaction rates will be measures in a new inclusive environment. The project is especially centered on user participation as recommended by Demirbilek (2004). Universal Design Evaluation (UDE) as found in Welch, (1995) and Lanchoti (2002) will guide the creation of assessment indicator. The project also proposes a social inclusion program through the introduction of assistance technologies. The UNICAMP program further has an educational element for the university community, especially within the professional courses of Civil Engineering, Architecture and Urban Design. These aspects should insure an increased environmental accessibility consciousness.

GOAL OF THE UNICAMP PROGRAM

General Goal

The general goal of the UNICAMP program is to promote environmental accessibility on campus, through, first of all a diagnosis of the situation and direct implementation of changes in the built environment, as well as educational programs to increase accessibility consciousness of university users and improve design knowledge in specific courses (Architecture and Civil Engineering).

Specific Goals

The Unicamp program will identify problems of architectural barriers on campus and how these may cause negative impacts for people with disabilities. This part of the program will also assess how barriers affect the quality of life and limit educational opportunities. As a second step the program will establish guidelines for the elimination of barriers and the creation of educational programs to implement attitude changes of the university public. The third step is geared towards a specific educational program for future design professionals. Specific courses and teaching methods will be created to augment design students awareness and technical know-how relating to Universal Design.

Once the problems of accessibility are identified the program will initiate the removal of barriers in the School of Civil Engineering, Architecture and Urban Design (FEC) with the participation of students. Once the School is considered barrier free, a building performance assessment will be performed and the user's perception evaluated.
As a final measure the guidelines, education program and barrier removal will be extended to the campus as a whole and lastly an evaluation will be conducted.

Program Methodology

The UNICAMP program will be implemented through the following steps:
1. A literature review will be conducted in specific areas: Universal Design, accessibility guidelines, barrier free university campi, UD instructional materials and teaching methods, building performance assessment, environmental psychology (perception, cognition, cultural and social impacts etc.) and environmental comfort.

2. Mapping of the accessibility situation on campus:

- Site plan of the University (zoning of built and green areas)
- Road system of the Campus (streets, parking areas, pedestrian walks, out door ramps and stairs, topographical level changes, vegetation, urban infrastructure, equipment and furniture, signs and communication elements as well as other barriers).
- Building stock assessment (existing building stock and construction projects).
- Building performance assessment (access (entrances and exits), circulation spaces (horizontal and vertical), public toilets, furniture and equipment, communication elements as well as orientation and exit signs).

3. Field Study:

- Development of questionnaires to assess user awareness and satisfaction with the campus.
- Pre-test and adjustments to the questionnaire.

- Sample dimensioning (total university population, stratification of users, persons with disabilities present on campus).
- Training of the field study team with the participation of building design students.
- Field study
- Data processing of results of the field study
- Analysis of results

4. Implementation of "Campus Action Plan":
   - Development of a campus user UD consciousness program (programs to impact the general university public's awareness and attitudes).
   - Creation of guidelines for the universities reception of users with disabilities. Special courses for course coordinators, librarians, laboratory technicians etc…
   - Introduction of barrier removal guidelines and creation of accessibility design solutions (library of architectural details).
   - Introduction of accessibility assessment indicators.

5. Implementation of "Barrier Removal Plan":
   - Design detailing of barrier removal in the School of Civil Engineering, Architecture and Urban Design (FEC) with the participation of Architecture and Civil Engineering Students.
   - Implementation of the barrier free design of FEC.
   - Design assessment: building and urban design evaluation of FEC.
   - User satisfaction assessment at FEC.
   - Analysis of FEC assessments and creation of an accessibility campus plan.

6. Implementation of an "Educational Program":
   - Development of teaching methods and course content for disciplines of UD in building design courses.
   - Creation of indicators for student design quality assessment.
   - UD discipline offerings in building design courses.
   - Evaluation of student design decision making processes pre and post "Barrier Removal Plan".
   - Evaluation of design quality of student projects pre and post "Educational Program".

7. Evaluation of impact of the total UNICAMP Program (community awareness changes, environmental quality changes, educational programs and activities).

8. Publication of results (University site, Scientific papers and national conferences on environmental comfort).

RESEARCH PLAN

The project (UNICAMP Program) will have a 24 month duration, with the methodological steps distributed according to the research plan below:

Steps	Months																						
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	■	■	■	■	■	■																		
2				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
3							■	■	■	■	■	■	■	■	■	■	■	■						
4											■	■	■	■	■	■	■	■	■	■				
5															■	■	■	■	■	■	■	■		
6				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
7																			■	■	■	■	■	
8																							■	■

UNICAMP Program status

The described research project is at present developing the following steps, Literature review, Mapping of accessibility situation on campus and the Campus Action Plan. The Educational Program and Barrier Removal Plan are also underway. The research team is primarily active in the Campus Action plan and The Educational Program and is supervising the Barrier Removal Plan of the Civil Engineering School.

The Campus Action plan is being developed in parallel with the educational program and special care is being taken to assure that ethical questions are being fully resolved in this research project. These questions involve the participation of persons with disabilities in the research project. The project must insure that risks are eliminated, possible medical treatment of participants is be interrupted or changed and the participants are free to abandon the project. The identity of participants is preserved and their participation is voluntary.

The Educational Program is under way through an undergraduate course being offered in the 2005 fall semester of the University, open to students from both the Civil Engineering and Architecture courses. The activities of the course include literature review by students, lectures and discussions on Universal Design and its impact on design in an environment of few resources and social and economic difficulties. Students are mapping the situation of the campus, especially in relation to the existence of architectural barriers by visiting primarily those facilities which serve the campus community as a whole (campus restaurant, main library, physical education facilities and two of the central classroom buildings). They are also collection data on user satisfaction in relation to the physical environment of UNICAMP. These activities are being conducted on a uniform platform of observation sheets and questionnaires for accountability of data. The course will further concentrate on awareness of students and increase their consciousness and engagement levels. As a final activity students will engage in a design project for the university (a Student Union) where the acquired know-how and consciousness is applied directly to future professional activities. This design project will concentrate on total inclusion of the Universal Design concepts and especially on the design process with the participation of users with disabilities. Here the course will concentrate on the visually impaired making students search for alternative and innovative design communication, other then the traditional drawings and models. These educational activities are based on the IOWA State University experience as described by Welch (1995).

The Barrier Removal Plan is being conducted through the University Design Office (*Coordenadoria de Projetos*) where three design projects are underway. The School of Civil Engineering building site is being remodelled through a new urban design scheme and an elevator is being introduced into the academic (student) building. For the Campus as a whole, the university architectural team is designing a "stock plan" which may be attached to most buildings on campus. This design includes an elevator, appropriate bathrooms, and other necessities (service and cleaning amenities as well as a small kitchen for coffee breaks) missing in most installations of UNICAMP today. In the Barrier Removal Plan the project team is also preparing the necessary documents for construction implementation in a public university. This included the preparation of specifications, financial planning and resource allocation.

CONCLUSION

This paper discusses the introduction of a program to improve the accessibility conditions of the University of Campinas, Brazil (UNICAMP). The program aims to remove barriers, create guidelines for accessible campi, increase user awareness to the principles of Universal Design and adopt new teaching strategies in building design courses. The program will be tested in one of the schools of UNICAMP and then extended to the whole university. Special impact assessment indicators will be created and a library of design solutions developed.

With this program we hope to improve the quality of life on campus for people with disabilities, and increase access to university education. The general university public's awareness and consciousness of barriers should also be influenced. With this program and especially its educational part the authors hope to contribute not only to improve the built environment of UNICAMP, but also to contribute to new ways of measuring the impact of barrier removal programs and teaching Universal Design, which should reflect in the quality of design professionals working in the local building construction industry.

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A USABILITY SUCCESS STORY?
THE CASE OF NORD TRONDELAG UNIVERSITY COLLEGE

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Abstract
Usability, with its focus on the users' perspective, is an important but often neglected aspect of building performance. In this paper we consider how usability affects performance of a building on the campus of Nord Trondelag University College, Norway. Our starting point for the case study is the ISO 9241-11 Ergonomics of human system Interaction (ISO 1998), where usability is defined as "the effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment." The case study building, Nylaana, was finished in 1999. It accommodates a library, canteen, staff offices and education facilities for three academic departments. We examined the building six years after completion, and studied the building performance seen from the user's perspective in relation to requirements in the program brief and the present use of the facilities. Our findings show a building that is considered to work very well. A questionnaire survey of staff and students placed the building in the top 3% of a UK benchmark dataset using a wide range of performance criteria. The comments in the questionnaire, interviews, and a review workshop including a walk-through, gave a more rounded qualitative picture, but even here the findings are quite complementary.

Keywords: Building performance, Post Occupancy Evaluation, University College, Usability.

INTRODUCTION

Buildings affect our health, our work, our thoughts and emotions. Each of us wants the buildings we use to support our individual needs. If organisational objectives are to be met as well, it is vital that we understand how these diverse and sometimes contradictory requirements can be matched to the performance of our buildings (Baird et al 1996). Conventional approaches to building performance usually deal with technical, functional and operational aspects. More recently, building performance appraisal has explored serviceability and accessibility to widen the remit (Davis et al.1993, Davis, Ventre 1990).

Usability is often a neglected aspect of building performance (Alexander et al 2004). In a North-European perspective this seems odd as planners, architects and facilities managers all tend to say that usability and manageability are a priority for them. Building owners also claim that functionality of workplaces is one of the important success factors for creating a good building. Larger organisations routinely perform regular investigations related to health, working environment, safety, user satisfaction and well-being. In spite of today's legislation, standards and measuring methods, many buildings still are suffering from serious failures and weaknesses in performance and function, and there is a significant potential for improvements (Jensø et al 2004). In the case study of Nylaana, we examined relationships between the briefing, planning and design phases and the use/ operation phase in order to explore the concept of usability in a more comprehensive framework. Generally speaking, did the building turn out as intended? Specifically, what were the successes and downsides, and the lessons learned? Our work has been part of CiB Task Group 51 Usability of Buildings established in 2001 in order to apply concepts of usability to provide a better understanding of user experiences of buildings.

WHAT MAKES A BUILDING USABLE?

The concept of "usability" is widely known in relation to applications within product design, information technology and web-design. Several aspects influence on a buildings usability. Figure 1 sets out a framework considering building usability with three main considerations developed from the ISO9241-11 Ergonomics of human system Interaction:
1. *Efficiency*, which splits into organisational factors such as the cost and quality of outputs, and building use factors like operating costs and intensity of use. To be 'usable' in the broadest sense, buildings need to operate within performance 'envelopes' which do not threaten the financial viability of the organisation.
2. *Effectiveness*, which is concerned mainly with adding value to existing products and/or services. One of the main purposes of buildings is to improve potential for the ways tasks are carried out and create conditions for innovation. This is productivity' in the broadest sense.
3. *Satisfaction*, which is whether building users are happy, healthy, safe and comfortable, and whether conditions are improved for 'customers' and visitors as well.

Efficiency		**Effectiveness**	**Satisfaction**	
Related to organisation	**Related to building**	**Added value**	**for employees**	**for customers**
Production time/cost per unit produced (services or products) Development time/cost of new products/ services Time/cost because of interruptions due to changes in the use of area	Operational cost/sqm Sqm/employee Number of users/ sqm/h Hours in use per day/week Time/costs per change in the use of area	Increased potential for…. Innovation Productivity Flexibility and adaptability Communication Learning/ development of knowledge Cooperation More distinct identity and image	Improved conditions. Personal well-being Personal efficiency at carrying out work tasks Air quality Lighting conditions Temperature Aesthetics Image and identity Functional performance	Improved….. Accessibility Image and identity Value of products and services Service quality

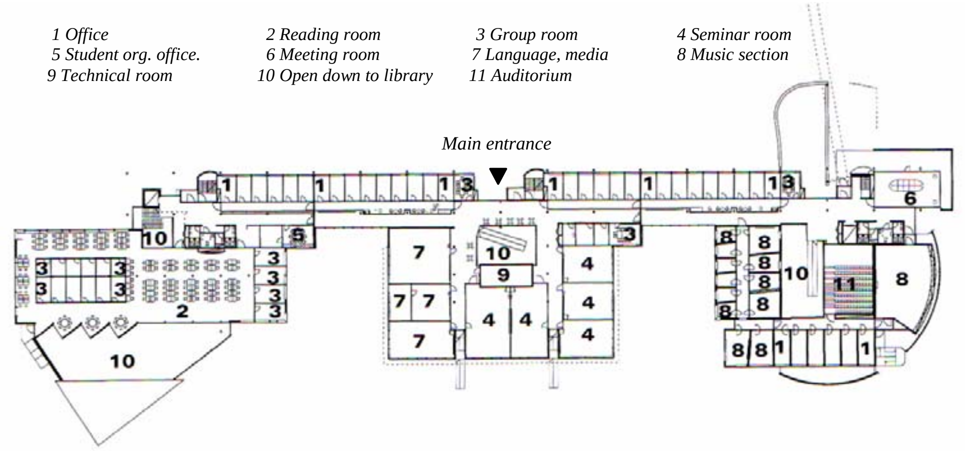
Figure 1: Framework for usability criteria

This framework was developed in a Norwegian workshop on usability (Arge 2004) using earlier more theoretical work (Alexander et al. 2004), (Jensø et al. 2004). An important outcome was the conclusion that usability should be related to organisational, technological and spatial factors in a wider framework, not just related to the individual user. It is important to distinguish between the terms functionality and usability. Functionality alone does not necessary make a building usable. Usability also depends on the situation, the context and the values of the designers and users. Both context and values change with time and place, and usability has to be seen from this perspective (Granath 2004). Good usability in buildings seen from the user's point of view depends on robust performance on basic factors like comfort and space provision. With the basic factors in place, the other factors tend to follow (Leaman 2000).

THE CASE STUDY

Nord Trondelag University College campus has a complex group of buildings, totally 28.000 m^2, of varying age and use. At present 2500 students and employees have their daily work at the campus. The case study Nylaana with offices for administration and teaching facilities has a total area 10.800 m^2. The planning process was initiated in 1992 by an open architectural competition. The winning project was "ABC", developed by HUS Architects of Trondheim. Then a long and difficult planning process arose, because of a lack of funding. In 1997 the project received the necessary funding from the ministry of education, and the planning and design could proceed. The hand over of the building took place 1999. As Figure 2 illustrates, "Nylaana" consists of three almost independent buildings, connected by a corridor with teachers' offices.

Figure 2 Nylaana first floor plan



The library and reading rooms are located in the south building volume (10), adjacent to the secondary entrance. The middle building volume is used for general teaching activities, with three auditoria, seminar rooms, media room, information technology and a language laboratory. Special rooms belonging to the different departments are gathered separately, in the north building volume (8).

RESEARCH METHODOLOGY

In the case study we have used a combination of four relevant and supplementary research methods: document analysis, a walk-through of the building, interviews with users and central actors in the building process, and an extensive user survey based on questionnaires.

Document analysis
The program for the architectural competition and the jury's evaluation and assessment was analysed In order to understand the intentions and requirements for the project. The document analysis was also important for comparative analysis of the program requirements, changes during the project development and the use of the building after completion.

Workshop and walk-through
The main purpose of the workshop was to discuss the concept of usability from different users' point of view, and to identify the users' criterions for evaluating the usability of Nylaana. In total nine user representatives from the staff, teachers, students and facility management were present. As a part of a four-hour workshop, we arranged a walk-through of the building. At eight different locations in the building, the users were asked to write down their positive and negative impressions regarding usability, together with suggestions for improvements.

Interviews
Interviews were conducted with participants from the design and planning phase (the architect and the project manager) and user representatives (the user coordinator and a user representative at the briefing stage). To explore the building in use, we interviewed four user representatives with different perspectives and functions in the building. The participants were selected from the group attending the workshop and the walk-through, making it possible to be more specific on usability related to their own workplace. Interviews dealt with user experiences from the study building in use, particularly the relationship between users' needs and what the building actually offered.

User survey
A user survey was developed, based on the existing standard occupant survey by Building Use Studies (Leaman 2005) to compare with UK dataset. Some minor adjustments were made to the standard questionnaire. In the building usability study we were assessing how the building works from the users perceive, especially in the ways it enables them to carry out their work effectively. Responses were obtained from 48 staff (response rate ca 85%) and 129 students (response rate app. 50%).

EXPERIENCES OF USING DIFFERENT METHODS

Workshop and walk-through
In our workshop and walk-through we had representatives from teachers, administration staff, students and FM staff. Together their knowledge covered a wide range from technical aspects to accessibility, functionality and user satisfaction.

In the preparation of the workshop and walk-through, the participants were asked to point out key factors relevant and essential for the building being suitable for different activities in a college facility. Not surprisingly, users gave different answers, reflecting their work tasks and experiences with the building. The users attached the following qualities to usability: contentment, functionality, accessibility, climate/indoor environment, satisfaction, independency and communication. Altogether the answers more or less covered all the three aspects of usability according to the ISO definition, without being detailed and exhaustive.

The workshop, including the walk-through, is a simple and rapid way to get the first overview and indications of the usability of the building. The walk-through has a visual approach, and the findings reflect this: the focus was on space, architecture, indoor climate and accessibility. The results from the walk-through and the quality of the evaluation will depend on who is participating, the preparations, the route for the walk-through and the focus of the evaluation. One of the participants had a physical handicap that helped us understand aspects of accessibility. Similarly, greater details came from the staff from the music and nursing departments in the group.

Users will naturally relate their opinions to their day-by-day experiences, while a designer will rely more on general knowledge about building use. Our discussion after the walk-through showed that the users had increased their understanding of usability, and also added management and productivity to their list of factors, which they thought were important.

Interviews

Interviews give the opportunity to go deeper and also to put the answers in a broader context for understanding the results. While the walk-through mainly was based on the participant's subjective and more ad hoc opinions of usability, the interviews were more structured. We used the definition of usability to systematically examine the effectiveness, efficiency and satisfaction.

From this case study, we experience that it is easier to get information about the users' satisfaction and the effectiveness of the building, than findings on the efficiency of the space. There was good accordance between the different interviewees' answers and comments on satisfaction and overall comfort. Regarding efficiency, the question of usability seems to be more dependent on different persons' perspectives and standpoints. What appears as usable and efficient from a students' point of view, does not necessarily mean the same to the teachers or the administrative staff. The four interviewees focused on their own departments, and responded on questions from that point of view. None of them had an overall perspective relating to the university as a whole. One reason might be the selection of interviewees, as none of the four represented strategic management. The findings from the walk-through tended to be confirmed, with more detailed information being added. The findings will depend on the selection of interviewees and which questions are asked. Here we see a greater need for a framework and a vocabulary that support an evaluation on usability.

Questionnaire

In this case study we used a questionnaire developed by Building Use Studies, used in many studies in the UK and worldwide. We were assessing how building users perceive how the building works, especially in which way it enables them to carry out their work effectively. The survey was carried out as the last part of the case study. Using this questionnaire gives us the opportunity to benchmark our case study against the UK dataset (no comparable Norwegian data are available). Detailed statistical findings from the staff survey may be viewed on www.usablebuildings.co.uk/619Charts/FrameSet.html.

The survey gave a comprehensive picture of the indoor environment of the building. We found that the survey gave some hints about the effectiveness of the building, but it is not specific enough to give detailed information on efficiency. This may reflect the difference in culture and focus on different aspect of usability between the Scandinavian countries and UK. In the questionnaire there also was room for comments. These comments give a broader picture of the different aspects of usability.

The question of what usability means, and how we can understand the concept is also essential in the design of a questionnaire exploring usability. This is directly related to the question of indicators and how we can measure usability in a certain building for a particular organisation at a specific time. From this case study we see a need for developing the questionnaire to give more answers regarding the efficiency and effectiveness of the building. Topics like way of working, need for space, need for technology, flexibility and adaptability would be more central in this survey.

DOES THE PROCESS AND USER INVOLVEMENT GIVE USEFUL RESULTS?
The Norwegian Directorate of Public Construction is responsible for organising, planning and completing building projects within a set framework for budgets, time limits and quality. The buildings must meet quality requirements for architecture, functionality and environmental concerns. Statsbygg has developed a comprehensive set of routines and guidelines for carrying out planning and building processes (Statsbygg 1996).

Findings from the case study, interviews with participants involved in the planning and design process, and check of the project management routines, show reasonable correlation between requirements set in the planning stage and the result of the building in use. When the planning and construction lasts for several years, discontinuity can be a problem. Changes in project management and user organisation caused frustrations among the participants. Changes in the user participation gave some problems due to new requirements coming up late in the process, and caused conflicts with decisions made earlier. Based on the four interviews, we cannot conclude that these changes affected the final results to a considerable extent.

Procedures and routines for the project management are quite detailed, with complex instructions on how to deal with different processes, information, documentation and decision-making. Even the fact that these procedures are present, does not necessarily mean the results are good if the routines are followed. A good example is user involvement. A user group was established, but their mandate was vague and not defined. The group reflected an average of the different users, rather than the right competence and experience for this kind of work. A competent and supported user group would probably have helped create a better programme. However, we should point out that the final design of the special rooms in the nursery education section and the music section seems to be quite successful.

Another aspect that seems to be missing is the involvement from a strategic level in the project throughout the whole process. This is especially important related to the two aspects of efficiency and effectiveness for the university college. A strategic discussion would also include a longer time perspective, and questions about future pedagogic principles, flexibility, adaptability and long-term change.

HOW WELL DOES THE BUILDING PERFORM?

The aim was to study how well Nylaana worked from the users' point of view to help learn lessons on usability for future design and management. This case study shows that the building in general gives a high degree of usability, but there are also several areas of potential improvement. The users involved in the workshop, walk-through and interviews had articulate opinions on both positive and negative aspects of the usability. Students tended to give lower ratings for most variables than staff. Even so, the results of the questionnaire were extremely positive. According to the summary report from Building Use Studies Ltd "the results were exceptional. When compared with the UK dataset, the building came in the top 3% of the dataset using a wide range of user performance criteria. The main lesson to be learned was that good usability in buildings depends on robust performance in basic factors like comfort and space provision. If the basics are in place, as they were here, other factors tend to follow, creating a virtuous circle. As such, this building was a model example" (Leaman 2005). Figure 3 shows the summary for main study variables concerning the comfort parameters.

5: Summary for main study variables used in short rating method, with comments.

Nyålana, HiNT	Staff			Students			
	Score	Better than benchmark?	Percentile (study building mean)	Score	Better than bench-mark?	Percentile (study building mean)	Comments
Overall comfort	5.02	Green	81	4.49	Green	62	Students find it more uncomfort-able in winter, and tend to give lower ratings for most vari-ables. Even so, the build-ing still scores very well.
Temperature in winter	5.07	Green	95	3.92	Amber	34	
Temperature in summer	4.58	Green	88	4.60	Green	91	
Air in winter	5.26	Green	99	4.35	Green	69	
Air in summer	5.03	Green	99	4.69	Green	96	
Lighting	6.12	Green	99	5.03	Green	88	
Noise	5.44	Green	98	4.72	Green	87	
Perceived productivity %	+3.35%	Green	80	+1.90%	Green	77	
Design	4.91	Green	57	5.10	Green	73	
Needs	5.19	Green	75	5.28	Green	76	
Health	4.47	Green	97	4.08	Amber	90	
Image	5.83	Green	71	5.22	Amber	36	
Details: Appendices A2, D2							

Figure 3. Report of building Usability survey, Building Use Studies Ltd.

The scores are based on mean values of responses to standard rating questions on 1-7 scales. The benchmarks are based on mean values of 50 recently studied buildings for the UK. Green means significantly better or higher, amber means no significant difference, and red means significantly lower or worse from benchmark and scale midpoint. Percentiles show where the building falls in the benchmark dataset. A building falling at the 95th percentile is in the top 5% of the dataset.

The results from the case study indicate that the building to a high degree support the activities. We also found that the users are very satisfied with the operation and the maintenance of the building, and that the staff responds to their problems. The building has become more and more functional being adjusted to the user needs.
The University College has had a significant increase in the number of students, but has been able to meet this increase by using the building more intensive and by widening the teaching period in the afternoon. But still there is a lack of smaller rooms, places for informal meetings and ad hoc activities.

Overall, the use of the building is still more or less the same as when completed in 1999. However, there has been a change in pedagogic practice with growing need to divide the large classes into smaller groups. There is now an increasing need for smaller seminar rooms. Nylaana was intended to provide improved range of possibilities for the students and staff. Different departments together in the same building should create opportunities for better communication and interaction across the older branches of study. The case study showed that those intentions still are not fulfilled. This is partly cultural based, and partly due to the fact that there are few possibilities for formal and informal meeting places in the building.

A USABILITY SUCCESS STORY?

An important question in this study was whether the building in use met the targets set in the brief. Both our case study and other surveys made on a national scale, show that students perceive the University College as an attractive place to study. The results from the study show that Nylaana is a building with many qualities that indeed do support the activities within. However, there is room for improvements of things that have been pointed out as negative and dysfunctional.

In this case we see there are some important conditions that influence usability. The programme brief for the architectural competition are guidelines for the master plan and the building design. The competition gave different answers to the program requirements regarding layout, with different opportunities and barriers. One of the arguments for choosing the winning concept was the opportunity to gather three different departments in one building. Another premise for the project was the total space budget and the investment budget for the building, giving a framework for developing the project.

We see that cultural aspects play an important role in the project. The deanery wanted the relocation of the three departments in the new building to give a synergy effect of more professional and social collaboration between the users. Even there is a lack of space for informal meetings in Nylaana; there are still mental barriers to a better interaction and communication between groups.

Usability depends on the different stakeholders' perspectives. The walk-through, interviews and survey all show that there are different opinions on the usability issues reflecting different the views of the students, teachers, administrators or the FM-staff. The findings show that users mainly are concerned about the space they use regularly. They are not necessarily so concerned about the building as a whole.

We found that staff responsible for operation and maintenance of the building has another view on the usability. They are more concerned about accessibility to the different technical systems, cleaning, security and maintenance. From the students' and the staffs' perspectives, it is essential that the technical staff understand users' needs to support their activities.

The study and earlier theoretical work indicates that the usability of a building is highly depending on the situation, the context and the different stakeholders perspectives and values. From this case study we find that Nylaana to a great extent must be regarded as a success story answering most of the users requirements.

ACKNOWLEDGEMENT
We would like to thank for the support from Statsbygg to carry out this usability research study, and are grateful for the collaboration with our colleagues in the CiB Task Group 51.

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DESIGNING FOR DISABILITY – A DANISH CASE STUDY ON DR BYEN

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Abstract
Considerations for the disabled have become increasingly important in most countries. The building codes set a number of requirements with a minimum standard, but these have been supplemented by various recommendations and guidelines. The requirements and recommendations vary from country to country. In Denmark a Danish Standard (DS 3028) with detailed recommendations on accessibility was issued in 2001. This paper gives a description of the way these recommendations were put into action in a current Danish building project. DR Byen is the new headquarters for DR (Danish Broadcasting Corporation) in Copenhagen, which is under construction at the moment. The project includes 130.000 sq. m divided into 4 parts, which have been designed by 4 different design teams. The complex has several areas with public access; including a concert hall and various studios. The paper provides an evaluation of the activities and measures in relation to disability considerations and draws conclusions in relation to the need of increased awareness and competencies on accessibility in the design process.

Keywords: Accessibility, disability, inclusive design, standards.

INTRODUCTION
The concept of accessibility has over the last decade become increasingly important in relation to disability and the built environment. The concept has changed the focus from dealing mainly with physical access for wheelchair users towards enabling people, including persons with disability, to participate in the social and economic activities for which the built environment is intended. Accessibility is a basic feature of the built environment concerning the way in which houses, public buildings, places of work etc. can be reached and used.

The purpose of this paper is to present a case study from a huge building project in Denmark, where comprehensive requirements for accessibility was integrated in the design process by involving a specialist architect experienced with accessibility aspects as a client consultant. The paper makes an evaluation of this process and makes conclusions in relation to the need for increased awareness among both clients and designers, as well as specialist competencies among designers. The author of the paper was until spring 2005 actively involved in the case study project as deputy project director with responsibility for, among other things, the client coordination of design in relation to disability. The paper has been developed in collaboration with the specialist architect consultant for the client in relation to disability considerations.

CODES, STANDARDS AND GUIDELINES
The Danish building codes from 1995 (Boligministeriet, 1995) introduced for the first time in Denmark accessibility as an essential consideration in building planning. Earlier safety and health were the main consideration in the planning of building layout

according to the building codes. The building codes from 1977 had, as a first step, introduced requirements for direct level access.

The development of increasing the focus on accessibility was international brought forward by the United Nations, who in 1993 agreed on Standard Rules on the Equalization of Opportunities for Persons with Disabilities (United Nations, 1994). A few years earlier the American government had passed ADA - The Americans with Disabilities Act (U.S. Department of Labor, 1991). The United Nations' Standard Rules have been officially adopted by, among others, all member states of the European Union. However, it is the general impression that there is a long way to go before the Standard Rules are fully implemented in most countries. This is at least the case in Denmark, although an increased political awareness is recognized.

The current building codes from 1995 contain a number of specific requirements in relation to accessibility, but also several requirements of intentional character. The Danish Standard organization issued a handbook (not a formally agreed standard) on accessibility with guidelines in 1995, but this only focused on outdoor areas, which was later supplemented by a collection of examples on design of recreational areas (Dansk Standard, 1995 and 1999). To supplement the building codes a number of Danish handicap organizations issued guidelines in 1996 on implementing the requirements in the building codes (Center for Ligebehandling af Handicappede, 1996).

More recently an official Danish Standard on accessibility was issued in 2001 (Dansk Standard, 2001). It is a comprehensive document with detailed requirements on all aspects of accessibility in relation to disability and the built environment. The Danish handicap organizations want the standard to become compulsory as part of the building codes, but the Danish government has decided that it should be voluntary for building clients to implement the rules. Thus the standard has the status of a guideline with recommendations. A number of guidelines on specific types of buildings have been published in recent years in Denmark, for instance for housing, museums, sports facilities and for special groups of people, for instance giving guidance to building clients and recommendations on accessibility for the blind and the elderly (Boplan, 2003).

There seems to be a lack of international standards on accessibility. There are a number ISO- and EN- standards on technical aids for handicapped, for instance walking aids, wheelchairs and beds. There are also national standards on accessibility and the built environment in various countries, but no comprehensive international standards on accessibility has yet been adopted. The only European standards concern accessibility to lifts in relation to safety rules for the construction and installation of lifts (Dansk Standard, 2003) and tactile identifiers (ETSI, 1998).

A general introduction to Danish disability policy written in English was issued in 2002. (Danish Disability Council, 2002). The Danish government issued a new action plan in relation to disability in February 2003 (Regeringen, 2003). Among the most important initiatives in relation to accessibility and the built environment was a test project with training consultants in accessibility, introducing an accessibility label for tourism facilities – recently broadened to all buildings with public access – together with a web portal (see http://www.godadgang.dk for further information in Danish and English) and changing the law and codes on building to cover some rebuilding project that must comply with certain accessibility requirements.

These actions have all been implemented. The amendments to the building law and codes came into force on 1. January 2005. They cover buildings with public access and buildings for service and administration. Rebuilding projects should implement direct level access, parking and toilets for disabled – and lifts only for buildings with public access - if the cost hereof does not exceed a certain percentage of the total rebuilding project cost.

DR BYEN

The building project in this case study is a new headquarters for DR, which is the main public service company in Denmark broadcasting radio and television. The project was initiated in 1999 and started with an international master plan competition in 2000 won by the Danish architect company Vilhelm Lauritzen A/S. The master plan is divided into four building segments dissected by an artificial canal crossing the site from north to south and a 12 meter wide connecting building – the internal street – from east to west, including an enclosed bridge over the canal on the second floor level.

Vilhelm Lauritzen A/S has been responsible for the design of segment 1, which is the largest segment, including several large television and drama studios, the internal street and the landscaping. The other segments have had separate architectural competitions. Segment 4 with the concert hall was won by the French architect Jean Nouvel, segment 2 by the Danish architect company Dissing + Weitling and segment 3 by a joint venture of two small Danish architect companies Gottlieb & Paludan + Nobel. The total project covers 130.000 sq. m including full basement. Except for the concert hall the complex is in general six stories high over terrain. Construction started early 2002 and building work on the first segment was finish in spring 2005, but installation of technology will not be finished before early 2006, when staff will start to move in. The other segments are under construction and will be finished in 2006 except for the concert hall. By the end of 2006 all DR's staff in the Copenhagen area is to be relocated to the new multimedia building.

DR has established a big internal client organization headed by a project director and with a combination of specialists from consulting companies, project employed and DR staff. The client organization is responsible for the overall project management in all stages of the project, including site management. DR has insisted on the implementation of environmental management, in accordance with ISO 14001, in the building project. The construction brief contains a large number of requirements in relation to environmental sustainability, including requirements to avoid hazardous products. Where possible, building materials with an indoor climate label should be used. In relation to disability this is of particular importance for people with allergic diseases.

Requirements on accessibility

In the first versions of the construction brief, from 2001, the requirements in relation to accessibility only referred to the building codes except for the external areas, where the earlier mentioned guidelines (Dansk Standard, 1995 and 1999) were made compulsory.

These versions were used as a basis for the design of segment 1. Later on the comprehensive Danish standard from 2001 (Dansk Standard, 2001) were included in the construction brief and has been a basis for the design of the other segments, the internal street and the landscaping. The text in the latest version of DR's general construction brief is as follows (in a non-authoritative English translation, including titles of the Danish publications; see references for original titles):

"It shall be possible for disabled people, even without help, to enter and leave the buildings by normal access routes, terraces and personnel entrances and to move around the areas surrounding the complex. It shall also be possible for disabled persons to move around and orient themselves in the buildings without special measures. Refer also to "Danish Building Regulations 1995 – About access requirements" (Center for Ligebehandling af Handicappede, 1996) and "Accessibility for all" (Dansk Standard, 2001) which applies to the whole building.

Recreational areas should be laid out such that disabled persons can access and use these areas. Outdoor areas shall be laid out in accordance with Danish Standard's "Outdoor areas for all - planning and design guidelines for providing access for disabled persons" (Dansk Standard, 1995), "Recreational areas for all – collection of examples" (Dansk Standard, 1999) and " Accessibility for all" (Dansk Standard, 2001)."

The responsibility to fulfil the requirements in the construction brief was designated to the architects of each segment in their contracts with DR.

THE IMPLEMENTATION PROCESS

DR's focus on accessibility was increased in spring 2003 following a letter from the chairman of DSI (De Samvirkende Invalideorganisationer – an umbrella organization for 31 different organizations in relation to disability in Denmark) to the chairman of DR's board. DSI had been contacted by one of the architects on DR BYEN, who wanted advice on disability considerations in the design. DSI informed DR in the letter that they did not have the necessary competencies to act as a consultant and recommended DR to involve a specialist handicap consultant in relation to the design of DR BYEN. Particularly, as the division of the project between different design teams causes a need for coordination between the different segments.

To clarify the situation DR arranged a meeting in June 2003 with representatives from DSI, handicap specialists, the architect teams and the client organization on DR BYEN. At the meeting DR outlined the requirements on accessibility in the construction brief, and the architects teams explained how they were working to comply with these requirements. The meeting revealed some problems in the design, for instance doors to handicap toilets opening inadequately, but the general conclusion was that DR was taking considerations for accessibility serious and had come a long way to implement the requirements in the Danish standard.

However, the need for involving a specialist consultant to coordinate the accessibility aspects on the different segments was not clarified at the meeting. DR's viewpoint was that the responsibility for the design should stay with the design teams. Following the meeting DR questioned each of the design teams, how they would make sure that their design complies with the requirements and what were their competencies to do so. The responses were very different. One team immediately reviewed their project on accessibility. Another team would involve a specialist consultant in the design work. Yet another team stated that they had the necessary competencies in their team without documenting it. The last team did not come up with a clear answer except that they would comply with the requirements.

DR decided on this basis that there was a need for involving a specialist consultant on the client side to review the design from the different teams to make sure, that the requirements were fulfilled. In the autumn of 2003 DR therefore contracted Erik Bahn and his architect company. He was one of the specialists participating in the meeting in June 2003 and he has extensive experience with designing for disability as well as good working relationships with Danish handicap organizations.

Immediately afterwards a review was made of the design projects of all the segments, independent of their stage of development. Later on, review of accessibility has been part of the general client review at the end of each stage of the design development, i.e. conceptual design, schematic design and detailed design. During spring 2005 the reviews of the detailed design of the four segments was almost finished, but reviews of the concert hall, the internal street and landscaping is still ongoing.

The reviews have mainly taken place as a check of project drawings from each design team providing written comments, which the design team replies on and the result is checked in the review at the next stage. On certain issues there have been meetings with a design team and the specialist consultant. In special cases the specialist consultant has produced sketches with possible solutions and improvements. The specialist consultant has also provided references to specialized information to the design teams. Below the main focus areas for the reviews on accessibility are described together with some examples of the most difficult problems in the process.

Parking

The supply of handicap parking spaces is a requirement in the building permit for the project. The main problem has been to get handicap parking placed near the main entrances. The specialist consultant has provided information of the necessary sizes and number of parking spaces for different types of handicap vehicles. The landscaping project is still under design development.

External access

The external access is particular difficult because the master plan holds an idea of placing the different buildings on a platform raised 30 cm above the surrounding terrain. This has made it necessary to integrate ramps for wheelchairs around the buildings. Direct level access has been made possible to the main entrance by raising the road and walkway locally in front of the entrance. Entrances to the building with the concert hall will also have direct level access. Another aspect of external access is accommodating people with reduced vision. The dialogue between the landscaping architects and the specialist consultant is ongoing in this respect.

Internal circulation
The concerns for internal circulation areas have mainly been to make sure that all corridors are 1,50 m wide, which is required in the Danish standard, while the requirements in the building codes are only 1,30 m for escape routes. Besides, the possibility to manoeuvre wheelchairs in other parts of the buildings has been checked.

Doors
The width of doors has also been an issue. Particularly because doors to production facilities for radio and television need to be soundproof, which reduces the effective opening space. This has been a problem in relation to access for wheelchair users.

Lifts and stairs
This has been one of the most difficult areas with considerable dialogue between the specialist consultant and the design teams. In relation to stairs there are specific requirement for the dimensions of steps, distance between steps, contrasting fronts of steps and shape of handrails, but often these requirements are unknown or neglected by the design teams. In relation to lifts there are similarly specific requirements on the dimensions of the car and the placing and design of control panels. Particularly the requirements of the control panels are generally unknown or neglected – even by producers of lifts. The new European standard in relation to lifts (Dansk Standard, 2003) has not yet been generally recognized. The requirements on control panels have also shown to be conflicting with some architects design ideas.

Due to this it has been hard work to get the requirements on stairs and lifts fulfilled. However, the specialist consultant also has an important role in interpreting the requirements and deciding what is needed and what is necessary to fulfil the intentions in the requirements on accessibility. Not all lifts or stairs need to comply with the accessibility requirements for disabled as long as all parts of the building is satisfactorily accessible.

Toilets
Although the requirements for layout of toilets are very specifically described in the Danish standard on accessibility, there has still been a need for a thorough review of the layout in the project design. Besides, the necessary number of toilets for disabled in special areas, for instance the staff restaurant, has been an issue of debate – also between the client and the specialist consultant.

Seating in concert hall
An area of strong concern among the representatives from organizations of disabled is the seating possibilities for wheelchair users in the concert hall. This became clear at the meeting in June 2003. The design team had planned areas for wheelchairs in the concert hall, but the representatives of the disabled found it very important, that wheelchair users could be seated next to their not disabled family members or friends. DR decided, that this request should be followed, and the design team plan that ordinary seats can be replaced with wheelchairs in specific rows in the concert hall.

Hearing aid in assembly rooms
In assembly rooms installation of a building integrated hearing aid system is required. This is usually designed as a loop wire system with one wire circuit around the perimeter of the room in question. However, such a system will create interference with microphones in radio and television studios as well as music facilities. It has therefore been a technical challenge to find systems suitable for DR's building.

The result has been a combination of conventional systems and so-called super-loop systems. These consist of a number of loops each covering a specific part of the room and each loop can be activated according to the actual need. In the concert hall both systems are used while super-loop systems are used in other music facilities and big studios with audience. A large meeting room has a conventional system.

It has been discussed whether building integrated hearing aid should be installed in foyer areas and the staff restaurant. The result is, that such systems are installed in two designated areas of 50 sq. m each in the concert hall foyer to be used for audience seating during foyer concerts. In other cases temporary systems will be put in place as needed.

Glass doors and walls
In modern buildings glass has become a very popular building material and that creates problems particular for people with reduced vision. Therefore, marking of glass doors and glass walls nearby has to be implemented. The main problem in the review has been to get the design teams aware of this and specify the areas where marking is needed.

Signage
The signage system in the buildings is being designed by DR BYEN's client organization with involvement of DR's internal design department. The specialist accessibility consultant collaborates with the person responsible for the signage project and has given advice; for instance on size of typography and colour contrasts. Use of tactile maps for external overview signage is under consideration.

CONCLUSIONS
Accessibility is an essential concept in relation to inclusive design and it has become increasingly important over the last 10 years – both politically and in practical building design. The requirements for accessibility have at the same time become much more comprehensive and increasingly complex. It has become a challenge for designers to find, understand and implement the huge amount of recommendations and guidelines.

However, there seems in general to be a lack of awareness among designers in relation to the need to take all necessary considerations for accessibility into account. Most architects and engineers have not been educated in this field and the complexity calls for involvement of specialists with specific competencies in relation to accessibility.
It is very important that considerations on accessibility are taken during the concept design development. If the requirements are implemented at an early stage, it becomes much easier to comply with them. The cost of the necessary measures will also be less if they are an integrated part of the building design. Many measures for accessibility for the disabled give general qualities to the building with benefits for all users over the

building's lifetime. For instance wider corridors and stairs make transport of furniture and equipment much easier. In contrast, if measures for disabled have to be implemented after the building is finished, it becomes very expensive. The case study shows that the cost of fees for involving a specialist consultant on accessibility is very small, approx. 0,1% of all consulting fees and 0,01% of the total budget.

Besides DR BYEN, a new opera house opened this year and a new theatre building is under construction in Copenhagen, both have involved a specialist consultant on accessibility (Rødsgaard, 2005). This follows a public criticism of a recent extension of the Danish National Art Museum, where accessibility has not been considered adequately.

The involvement of a specialist consultant makes sure that the essential knowledge is integrated in the project team to comply with the requirements on accessibility. It also gives the possibility to optimize the design by interpreting the requirements and deciding what is needed and what is necessary to fulfil the intentions in the requirements on accessibility. This requires professional experience, but education of designers in accessibility is a very important starting point to get an appropriate number of specialists. Furthermore, an increased awareness among clients on accessibility is important to make building design companies and individual designers give this due consideration.

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THE INFLUENCE OF CONCEPT DESIGN ON CONSTRUCTION HEALTH AND SAFETY

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Abstract
Construction is a multi-stakeholder process and consequently by virtue of participation, all stakeholders, architectural designers included, influence the construction process. Designers influence H&S directly and indirectly. Directly as a result of design, supervisory and administrative interventions, and indirectly, as a result of type of procurement system adopted, pre-qualification, project time, partnering and the facilitating of pre-planning. Furthermore, the South African Construction Regulations require that designers modify the design or make use of substitute materials where the design necessitates the use of dangerous structural or other procedures or materials hazardous to H&S. However, a key issue is that concept design dictates the selection of type of structural frame, general design, details, and materials, impacts on constructability, and has a substantial influence on temporary works. The paper reports on the exploratory phase of a descriptive survey conducted among best practice H&S general contractors to investigate the influence of design and concept design on construction H&S and the consideration therefore. Findings indicate that design and concept design effect construction H&S and that generally architects do not consider construction H&S.

Keywords: Architects, concept design, construction, health and safety, influence.

INTRODUCTION
Cost, quality and time tend to constitute the parameters within which projects are managed. However, increasing awareness relative to the role of H&S in overall project performance and the inclusion of H&S as a project performance measure by better practice clients has engendered focus on H&S by a range of stakeholders. The number of large-scale construction accidents in South Africa in recent years and the consequential media coverage has further raised the level of awareness. Construction 'blitzes' undertaken by the Occupational Health and Safety Inspectorate, Department of Labour, determined a large amount of non–compliance to H&S legislation by the construction industry. Furthermore, the Construction Regulations promulgated on the 18 July 2003, require a range of interventions by the various stakeholders. Designers are required to inter alia, substitute hazardous materials, modify designs that require the use of dangerous structural or other processes, and consider ergonomics and the H&S of workers throughout all phases of projects.

Design occurs upstream of construction, commissioning and use of a completed structure. Furthermore, design is a linear process and thus develops from the concept and initiation phase through the detailed design phase. The paper reports on the exploratory phase of a study initiated to investigate the effect of design and concept design on construction H&S, and the extent to which architects consider construction H&S relative to various design and concept design related aspects.

Project phases
Due to projects being unique and involving a certain degree of risk, the Project Management Body of Knowledge (PMBOK) recommends that they be subdivided into several phases to provide for better management control. The four phases which are collectively referred to as the project life - cycle are: concept and initiation; design and development; implementation or construction, and commissioning and handover (Project Management Institute, 2000).

Legislation and recommended practice
The Construction Regulations (Republic of South Africa, 2003) lay down important requirements with respect to designers. Designers shall, inter alia:

- make available all relevant information about the design such as the soil investigation report, design loadings of the structure, and methods and sequence of construction; inform principal contractors of any known or anticipated dangers or hazards or special measures required for the safe execution of the works, and
- modify the design or make use of substitute materials where the design necessitates the use of dangerous structural or other procedures or materials hazardous to H&S.

The International Labour Office (1992) specifically states that designers should:

- receive training in H&S;
- integrate the H&S of construction workers into the design and planning process;
- not include anything in a design which would necessitate the use of dangerous structural or other procedures or hazardous materials which could be avoided by design modifications or by substitute materials, and
- take into account the H&S of workers during subsequent maintenance.

Furthermore, the requirements of clients in terms of the Construction Regulations indirectly require contributions from designers. Clients shall, inter alia:

- prepare H&S specifications for the construction work;
- ensure that principal contractors have made provision for H&S costs in their tenders;
- provide principal contractors with any information that might affect H&S;
- appoint principal contractors for projects,
- ensure that principal contractors implement their H&S plans;
- stop work that is not in accordance with the H&S plans, and
- ensure that sufficient H&S information and resources are available to the principal contractor where changes to the design or construction are made.

THE INFLUENCE OF DESIGN
According to Jeffrey and Douglas (1994) it has to be accepted that there is a causal link between design decisions and safe construction. This is based on research conducted by the European Foundation for the Improvement of Living and Working conditions, which concluded that 35% of site fatalities were caused by falls that could have been reduced through design decisions. Schneider and Susi (1994) say that constructing a new building is, by its very nature, a problem in ergonomics as construction involves work at floor and

ceiling level requiring kneeling, bending, reaching out, twisting and the adopting of uncomfortable work postures. Designers influence H&S directly through design specific, supervisory and administrative interventions. Design specific interventions include:

- concept design,
- general design,
- selection of type of structural frame,
- site location,
- site coverage,
- details,
- method of fixing, and
- specification of materials and finishes.

Supervisory and administrative interventions include:

- reference to H&S upon site handover and during site visits and inspections,
- inclusion of H&S as an agenda item during site meetings, and
- the requiring of H&S reporting by contractors.

Designers also influence H&S indirectly through:

- type of procurement system used,
- prequalification,
- project time,
- partnering, and
- the facilitating of pre-planning (Smallwood, 2000).

A further role identified for designers is that of optimal interaction with clients, particularly at the design brief stage, the most crucial phase for the successful and healthy and safe completion of any project. In essence, the design brief is the inception of concept design, and Jeffrey and Douglas (1994) contend that deviations from it at a later stage resulting in variation orders can be the catalyst that triggers a series of events from designer through to workers that culminate in an accident on site.

Designers also influence the pre-planning of H&S. Pre-planning identifies all the ingredients of and resources required for the H&S programme to be effective and efficient. However, the design of a project is a great influence on determining the method of construction and the requisite H&S interventions. Consequently, designers need to make sufficient design related information available at pre-project stage to facilitate budgeting for adequate resources (Liska, 1994).

Constructability is a further design related issue. ‘Design for safe construction’ is one of 16 constructability design principles listed by Adams and Ferguson (McGeorge and Palmer, 2002). However, most of the other 15 principles are indirectly related to, and consequently influence H&S. Method of fixing, size, mass and area of materials, position of components, amplify the relevance of constructability to H&S.

CONCEPT DESIGN

Although detailed design has a substantial influence on H&S in terms of constructability, method of fixing, materials specified and processes required, concept design effectively establishes a precedent as it establishes the shape on plan, elevations, height, type of enclosing fabric, and influences the choice of structural frame. Illustration 1 below depicts balconies projecting beyond the primary extremity of the structure. The photograph, which was taken in the Victoria and Alfred Waterfront, Cape Town, South Africa, illustrates the impact of the 'concept' marine theme adopted for the project on the design, and construction H&S. The issue being that the projecting balconies are intended to represent the forecastles on ships. However, research indicates that projections on plan are not complementary to construction H&S as workers are exposed to irregularities in terms of plan layout (Hinze, 1997).

Illustration 1: Projecting balconies to apartments (Photo credit, Smallwood).

Research conducted by Smallwood (2003) investigated the frequency at which architectural practices consider / refer to H&S on various occasions relative to a range: never; rarely; sometimes; often, and always. Given that the importance index of 1.82 / 4.00 was below the midpoint of the range architectural practices can generally be deemed not to consider / refer to H&S. However, given that the important index is $> 1.60 \leq 2.40$, the architectural practices can be deemed to consider / refer to H&S between rarely to sometimes / sometimes.

RESEARCH

Sample stratum and response

The sample stratum consisted of 26 general contractors (GCs), that had achieved a place in the Building Industries Federation South Africa (BIFSA) national Health and Safety (H&S) competition and, or a BIFSA 4 or 5-Star H&S grading on one or more of their projects, for the years 1995 to 2000 inclusive. Approximately one third of GCs responded to a postal survey – the initial survey was followed by a further request to respond.

Analysis
The analysis of the data consisted of the calculation of descriptive statistics to depict the frequency distribution and central tendency of responses to fixed response questions to determine the impact and effect of various concept design and design related aspects on construction H&S respectively, and the extent to which architects consider/refer to them relative to H&S. Given that effectively a six-point scale ('never' linked to a five-point) was used and that the difference between 0 and 5 is five, ranges with an extent of 0.8 (5 / 6) are used to discuss the degree of central tendency. The ranges relative to the mean score categories is as follows:

- $> 4.17 \leq 5.00$ - between a near major to major / major effect or extent or impact;
- $> 3.33 \leq 4.17$ - between an effect or some extent or impact to near major / near major effect or extent or impact;
- $> 2.50 \leq 3.33$ - between a near minor to an effect or some extent or impact / an effect or some extent or impact, and
- $> 1.67 \leq 2.50$ - between a minor to near minor / near minor effect or extent or impact.

Findings
Table 1 indicates the perceived extent to which twenty design related aspects affect construction H&S in terms of percentage responses to never and a range of 1 (minor) to 5 (major), and in terms of a mean score ranging between 0 and 5. It is notable that nineteen of the mean scores are above the midpoint score of 2.50, which indicates that in general the respondents perceive the design related aspects to affect construction H&S.

Height of building / structure predominates, and given that the mean score is 4.25 respondents can be deemed to perceive it to have a near major to major / major effect on construction H&S. This mean score is probably attributable to the implications of working at elevated heights, not least the risks.

Those design related aspects ranked second to joint ninth can be deemed to have between an effect to near major effect / near major effect on construction H&S. Pitch of roof in the form of a steep pitch affects construction H&S throughout all phases of a structure's life in terms of the fixing of the roof covering and allied sub-strata and support. Incorporation of a basement introduces bulk excavations, elevated edges thereto, lateral restraint and the risk of collapse should the former be inadequate, and possible exposure to services such as electricity, gas, water, and telecommunications, and ground or other water. Furthermore, rock may be encountered resulting in drilling and / or breaking, and possible exposure to noise. Type of structural frame affects H&S as the four primary types, namely load bearing masonry, reinforced concrete (RC), structural steel, and timber frame, all have inherent characteristics. Load bearing masonry entails the production, transporting, movement, handling and laying of a large number of individual units, which sometimes are not optimum in terms of size and mass. Furthermore, masonry units involve the wet trades, which constitute a challenge in terms of storage of aggregates and housekeeping. Position of components affects lifting and handling, and may require work at elevated heights. Site location affects construction H&S as a result of geotechnical and prevailing weather conditions. Furthermore, the site may be adjacent to, and the project may require the construction of a structure over water. In terms of construction H&S, the concept design creates the framework for a structure as it establishes the shape on plan, elevations, height, type of enclosing fabric, and influences the choice of structural frame. Method of fixing dictates the type of plant and equipment required, affects the body posture adopted, and may entail exposure to noise and hazardous chemical substances. Both elevations and specifications marginally fall within this range. Elevations effect construction H&S as a result of the nature of work arising from the enclosing fabric, details and features. Specifications influence body posture and movement.

The design related aspects ranked joint eleventh to nineteenth can be deemed to have between a near minor effect to an effect / effect on construction H&S. Plan layout influences H&S as a result of the number of contained areas per floor level, which impacts on the extent to which the requisite resources can be accommodated. Furthermore, plan layout effects the erection of scaffolding to say semi-circular elements. Details, schedule, and finishes influence body posture and movement. General design influences a range of aspects as it establishes pre-requisites in terms of the physical realization of the design. Certain materials have sharp edges; the surface area of certain materials can result in difficulty in handling, and the mass of certain materials can present a manual materials handling problem. In terms of content of materials, materials may contain hazardous chemical substances (HCSs). Texture of material can be deemed to have between a minor to near minor / near minor effect on construction H&S. A rough texture to certain materials constitutes a hazard to workers.

Table 1: The effect of various design related aspects on construction H&S

Aspect	Unsure	Never	Minor ……………………………. Major					Mean score	Rank
			1	2	3	4	5		
Height of building / structure	0.0	0.0	12.5	0.0	0.0	25.0	62.5	4.25	1
Pitch of roof	0.0	0.0	12.5	0.0	25.0	12.5	50.0	3.88	2
Incorporation of basement	0.0	0.0	0.0	12.5	25.0	37.5	25.0	3.75	3=
Type of structural frame	0.0	0.0	0.0	12.5	12.5	62.5	12.5	3.75	3=
Position of components	0.0	12.5	0.0	0.0	0.0	62.5	25.0	3.75	3=
Site location	0.0	0.0	12.5	0.0	12.5	62.5	12.5	3.63	6
Concept design	12.5	0.0	0.0	25.0	12.5	37.5	12.5	3.43	7=
Method of fixing	0.0	14.3	0.0	0.0	14.3	57.1	14.3	3.43	7=
Elevations	0.0	0.0	12.5	0.0	25.0	62.5	0.0	3.38	9=
Specifications	0.0	0.0	0.0	25.0	25.0	37.5	12.5	3.38	9=
Plan layout	0.0	0.0	12.5	12.5	25.0	50.0	0.0	3.13	11=
Details	0.0	0.0	0.0	12.5	62.5	25.0	0.0	3.13	11=
Edge of materials	0.0	12.5	0.0	25.0	0.0	50.0	12.5	3.13	11=
General design	0.0	0.0	12.5	12.5	37.5	37.5	0.0	3.00	14=
Mass of materials	12.5	12.5	0.0	12.5	12.5	50.0	0.0	3.00	14=
Finishes	0.0	0.0	25.0	25.0	0.0	37.5	12.5	2.88	16
Schedule	12.5	0.0	12.5	25.0	25.0	12.5	12.5	2.86	17
Surface area of materials	0.0	12.5	0.0	12.5	50.0	25.0	0.0	2.75	18
Content of material	12.5	12.5	12.5	12.5	12.5	37.5	0.0	2.57	19
Texture of materials	12.5	12.5	12.5	12.5	37.5	12.5	0.0	2.29	20

Table 2 indicates the perceived extent to which architects consider construction H&S relative to twenty design related aspects in terms of percentage responses to never and a range of 1 (minor) to 5 (major), and in terms of a mean score ranging between 0 and 5. It is notable that with the exception of height of building / structure all the mean scores are below the midpoint score of 2.50, which indicates that in general the respondents perceive the extent of consideration of construction H&S relative to the design related aspects by architects to be between never to near minor / near minor. However, those aspects ranked second to joint fifteenth (> 1.67 ≤ 2.50) are perceived to be considered between a minor to near minor / near minor extent.

Table 3 indicates that all the mean scores relative to the affect of various design related aspects on H&S are all greater than the mean scores relative to the extent to which architects consider such design related aspects. Further, the absolute percentage gap between the 'effect' and 'consider' mean scores on the scale of 0.00 to 5.00 has been presented e.g. relative to height of building / structure: (4.25 – 2.63) / 5.00 = 32.4%.

Table 2: The extent to which architects consider construction H&S relative to various design related aspects

Aspect	Unsure	Never	Minor ……………………………… Major					Mean score	Rank
			1	2	3	4	5		
Height of building / structure	0.0	12.5	12.5	12.5	25.0	37.5	0.0	2.63	1
Type of structural frame	0.0	12.5	12.5	12.5	50.0	12.5	0.0	2.38	2
Concept design	0.0	12.5	12.5	25.0	37.5	12.5	0.0	2.25	3=
Pitch of roof	0.0	12.5	12.5	37.5	12.5	25.0	0.0	2.25	3=
Incorporation of basement	0.0	12.5	12.5	37.5	25.0	12.5	0.0	2.13	5=
Elevations	0.0	12.5	12.5	37.5	25.0	12.5	0.0	2.13	5=
General design	0.0	12.5	12.5	37.5	37.5	0.0	0.0	2.00	7=
Specifications	0.0	12.5	25.0	25.0	25.0	12.5	0.0	2.00	7=
Mass of materials	0.0	12.5	0.0	62.5	25.0	0.0	0.0	2.00	7=
Position of components	12.5	12.5	0.0	50.0	25.0	0.0	0.0	2.00	7=
Plan layout	0.0	12.5	25.0	37.5	12.5	12.5	0.0	1.88	11=
Method of fixing	0.0	12.5	25.0	25.0	37.5	0.0	0.0	1.88	11=
Surface area of materials	12.5	12.5	0.0	62.5	12.5	0.0	0.0	1.86	13=
Edge of materials	12.5	12.5	12.5	37.5	25.0	0.0	0.0	1.86	13=
Site location	0.0	25.0	12.5	25.0	37.5	0.0	0.0	1.75	15=
Details	0.0	12.5	25.0	37.5	25.0	0.0	0.0	1.75	15=
Schedule	0.0	12.5	25.0	37.5	25.0	0.0	0.0	1.75	15=
Finishes	0.0	12.5	12.5	62.5	12.5	0.0	0.0	1.75	15=
Texture of materials	0.0	12.5	12.5	62.5	12.5	0.0	0.0	1.75	15=
Content of material	12.5	12.5	25.0	50.0	0.0	0.0	0.0	1.43	20

Table 3: Comparison of the effect of various design related aspects on construction H&S and the extent to which architects consider them

Aspect	Mean score			Rank	
	Effect	Consi-der	Gap (%)	Effect	Consi-der
Height of building / structure	4.25	2.63	32.4	1	1
Pitch of roof	3.88	2.25	32.6	2	3=
Incorporation of basement	3.75	2.13	32.4	3=	5=
Type of structural frame	3.75	2.38	27.4	3=	2
Position of components	3.75	2.00	35.0	3=	7=
Site location	3.63	1.75	37.6	6	15=
Concept design	3.43	2.25	23.6	7=	3=
Method of fixing	3.43	1.88	31.0	7=	11=
Elevations	3.38	2.13	25.0	9=	5=
Specifications	3.38	2.00	27.6	9=	14=
Plan layout	3.13	1.88	25.0	11=	11=
Details	3.13	1.75	27.6	11=	15=
Edge of materials	3.13	1.86	25.4	11=	13=
General design	3.00	2.00	20.0	14=	7=
Mass of materials	3.00	2.00	20.0	14=	7=
Finishes	2.88	1.75	22.6	16	15=
Schedule	2.86	1.75	22.2	17	15=
Surface area of materials	2.75	1.86	17.8	18	13=
Content of material	2.57	1.43	22.8	19	20
Texture of materials	2.29	1.75	10.8	20	15=

Table 4 indicates the perceived extent to which fourteen concept design related aspects affect construction H&S in terms of percentage responses to never and a range of 1 (minor) to 5 (major), and in terms of a mean score ranging between 0 and 5. It is notable that all the mean scores are above the midpoint score of 2.50, which indicates that in general the respondents perceive the concept design related aspects to affect construction H&S.

Height of building/structure predominates, and given that the mean score is 4.38 respondents can be deemed to perceive it to have a near major to major / major effect on construction H&S.

Those concept design related aspects ranked joint second to ninth (> 3.33 ≤ 4.17) can be deemed to have between an effect to near major / near major effect on construction H&S, and those ranked joint tenth to fourteenth (> 2.50 ≤ 3.33) between a near minor to an effect / an effect.

Generally, those concept design aspects common to design have more of an effect during concept design than design in general.

Table 4: The extent to which various concept design related aspects impact on construction H&S

Aspect	Unsure	Never	Minor ……………………………. Major					Mean score	Rank
			1	2	3	4	5		
Height of building / structure	0.0	0.0	0.0	0.0	0.0	62.5	37.5	4.38	1
Incorporation of basement	0.0	0.0	0.0	12.5	12.5	25.0	50.0	4.13	2=
Type of structural frame	0.0	0.0	0.0	0.0	0.0	87.5	12.5	4.13	2=
Site location e.g. side of hill, adjacent to water	0.0	0.0	0.0	12.5	0.0	62.5	25.0	4.00	4=
Type of foundations	0.0	0.0	0.0	0.0	25.0	50.0	25.0	4.00	4=
Pitch of roof	0.0	0.0	0.0	0.0	25.0	50.0	25.0	4.00	4=
Projections e.g. balconies, canopies	0.0	0.0	0.0	0.0	12.5	75.0	12.5	4.00	4=
Enclosing fabric	0.0	0.0	0.0	0.0	57.1	28.6	14.3	3.57	8
Shape on plan e.g. circular, semi-circular	0.0	0.0	12.5	12.5	12.5	50.0	12.5	3.38	9
Type of fenestration	0.0	0.0	0.0	25.0	37.5	25.0	12.5	3.25	10=
Materials	0.0	0.0	0.0	37.5	12.5	37.5	12.5	3.25	10=
Floor heights	0.0	0.0	0.0	37.5	12.5	37.5	12.5	3.25	10=
Type of partitioning e.g. brick, drywall	0.0	0.0	12.5	37.5	0.0	37.5	12.5	3.00	13
Area of floors	0.0	0.0	12.5	25.0	37.5	12.5	12.5	2.88	14

Table 5: The extent to which architects consider construction H&S relative to various concept design related aspects

Aspect	Unsure	Never	Minor ……………………………. Major					Mean score	Rank
			1	2	3	4	5		
Height of building / structure	0.0	12.5	12.5	12.5	50.0	12.5	0.0	2.38	1
Pitch of roof	0.0	12.5	12.5	25.0	37.5	12.5	0.0	2.25	2
Type of structural frame	0.0	12.5	12.5	25.0	50.0	0.0	0.0	2.13	3=
Shape on plan e.g. circular, semi-circular	0.0	12.5	12.5	37.5	25.0	12.5	0.0	2.13	3=
Incorporation of basement	0.0	12.5	12.5	37.5	37.5	0.0	0.0	2.00	5=
Projections e.g. balconies, canopies	0.0	12.5	12.5	37.5	37.5	0.0	0.0	2.00	5=
Enclosing fabric	0.0	12.5	12.5	37.5	37.5	0.0	0.0	2.00	5=
Site location e.g. side of hill, adjacent to water	0.0	25.0	12.5	12.5	50.0	0.0	0.0	1.88	8=
Type of foundations	0.0	12.5	12.5	50.0	25.0	0.0	0.0	1.88	8=
Type of fenestration	0.0	12.5	12.5	50.0	25.0	0.0	0.0	1.88	8=
Floor heights	0.0	12.5	12.5	62.5	12.5	0.0	0.0	1.75	11=
Type of partitioning e.g. brick, drywall	0.0	12.5	12.5	62.5	12.5	0.0	0.0	1.75	11=
Materials	0.0	12.5	25.0	50.0	12.5	0.0	0.0	1.63	13=
Area of floors	0.0	12.5	25.0	50.0	12.5	0.0	0.0	1.63	13=

Table 6: Comparison of the effect of various concept design related aspects on construction H&S and the extent to which architects consider them

Aspect	Mean score			Rank	
	Effect	Consider	Gap (%)	Effect	Consider
Height of building / structure	4.38	2.38	40.0	1	1
Incorporation of basement	4.13	2.00	42.6	2=	5=
Type of structural frame	4.13	2.13	40.0	2=	3=
Site location e.g. side of hill, adjacent to water	4.00	1.88	42.4	4=	8=
Type of foundations	4.00	1.88	42.4	4=	8=
Pitch of roof	4.00	2.25	35.0	4=	2
Projections e.g. balconies, canopies	4.00	2.00	40.0	4=	5=
Enclosing fabric	3.57	2.00	31.4	8	5=
Shape on plan e.g. circular, semi-circular	3.38	2.13	25.0	9	3=
Type of fenestration	3.25	1.88	27.4	10=	8=
Materials	3.25	1.63	32.4	10=	13=
Floor heights	3.25	1.75	30.0	10=	11=
Type of partitioning e.g. brick, drywall	3.00	1.75	25.0	13	11=
Area of floors	2.88	1.63	25.0	14	13=

CONCLUSIONS

Although the findings reported on emanate from the exploratory phase of a study, they have their origin in a sample of 'better practice H&S' GCs. Construction H&S contributes to and influences overall performance. However, in terms of the recently promulgated Construction Regulations, designers are required to undertake a range of interventions relative to construction H&S. Many of these are influenced by concept design and / or detailed design.

The empirical findings indicate that the predominating design related aspects that effect construction H&S are aspects that are primarily influenced through the concept design. However, there is a considerable 'gap' between the extent to which architects consider construction H&S relative to the design related aspects and the effect of the latter on construction H&S. Similarly, there is a considerable 'gap' between the extent to which architects consider construction H&S relative to the concept design related aspects and the effect of the latter on construction H&S.

A notable finding is that although the ranking of aspects which are common to both design and concept design are common, the mean scores of the latter are higher, which indicates that their influence is more pronounced at concept than detailed design stage.

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THE IMPACT OF THE CONSTRUCTION REGULATIONS: ARCHITECTS' PERCEPTIONS

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Abstract
International research indicates that clients, project managers, designers, and quantity surveyors influence and can contribute to construction H&S. The promulgation of the South African Construction Regulations in July 2003 realised client, designer, and quantity surveyor responsibility for H&S. Clients are required to inter alia, provide the principal contractor (PC) with an H&S specification, and ensure that PCs have made adequate allowance for H&S. Designers are required to inter alia, provide the client with all relevant information about the design, which will affect the pricing of the works, inform the contractor of any known or anticipated dangers or hazards, provide the contractor with a geo-science technical report, and the methods and sequence of construction, and modify the design where dangerous procedures would be necessary, or substitute hazardous materials. Given the passing of the first anniversary of the promulgation of the Construction Regulations, a survey was conducted to determine the perceptions of member practices of the South African Institute of Architects (SAIA). Findings include: the traditional project parameters in the form of cost, quality, and time are still perceived to be substantially more important than H&S; the manifestations of the impact of the Construction Regulations are wide spread - increased H&S awareness predominates among the manifestations, followed by increased consideration for H&S by most stakeholders, and H&S predominates in terms of the extent to which the Construction Regulations will impact on various project parameters.

Keywords: Architects, construction, health and safety

INTRODUCTION

Increasing awareness relative to the role of H&S in overall project performance and the inclusion of H&S as a project performance measure by inter alia, petro–chemical organisations, has engendered focus on H&S by a range of stakeholders. The number of large-scale construction accidents in South Africa during the last decade and more, and the consequential media coverage has further raised the level of awareness. Furthermore, the Construction Regulations promulgated on the 18 July 2003, require a range of interventions by clients and designers.

Given the abovementioned, the general need to assess the impact of interventions, and the first anniversary of the promulgation of the Construction Regulations, a survey was conducted to determine the perceptions of member practices of the South African Institute of Architects (SAIA) regarding:

- the importance of various project parameters;
- the manifestation of the impact of the Construction Regulations, and
- the extent to which the Construction Regulations will impact on various project parameters.

LITERATURE SURVEY

Statistics

During 1999, the latest year for which occupational injury statistics are available, a total of 14 418 medical aid cases, 4 587 temporary total disablements, 315 permanent disablements, and 137 fatalities were reported to the Compensation Commissioner in South Africa (2005). These equate to 1 temporary disablement for every 102 workers, 1 permanent disablement for every 1 041, and 1 fatality for every 3 925. The disabling injury incidence rate (DIIR) 0.98 means that 0.98 workers per 100 incurred disabling injuries, the all industry average being 0.78. The number of fatalities among the workers insured by the Accident Fund (AF) is the equivalent of a fatality rate of 25.5 fatalities per 100 000 full-time equivalent construction workers, which does not compare favourably with international rates.

The severity rate (SR) indicates the number of days lost due to accidents for every 1 000 hours worked. The construction industry SR 1.14 is the fourth highest, after fishing, mining, and transport, the all industry average being 0.59. Given that the average worker works 2 000 hours per year, if the SR is multiplied by 2, the average number of days lost per worker per year can be computed – the construction industry lost 2.28 working days per worker during 1999. This is equivalent to 1.0% of working time.

The statistics provide the humanitarian motivation for the: need for occupational health and safety related legislation; promulgation of the Construction Regulations, and need for multi-stakeholder contributions to construction H&S.

Legislation and recommendations pertaining to architects

Prior to the promulgation of the Construction Regulations, Section 10 of the Occupational Health and Safety Act (OH&S Act) required to designers to ensure that any 'article' is safe and without risks to health (Republic of South Africa, 1993). However, the required contribution to construction H&S was implied, whereas the Construction Regulations schedule explicit requirements of designers, inter alia (Republic of South Africa, 2003):

- make available all relevant information about the design such as the soil investigation report; design loadings of the structure, and methods and sequence of construction;
- inform principal contractors of any known or anticipated dangers or hazards or special measures required for the safe execution of the works, and
- modify the design or make use of substitute materials where the design necessitates the use of dangerous structural or other procedures or materials hazardous to H&S.

Furthermore, the safety and health in construction guidelines published by the International Labour Office (ILO) (1992) effectively state that designers should consider / refer to H&S.

In terms of the Construction Regulations clients shall, inter alia:

- prepare H&S specifications for the construction work;

- ensure that principal contractors (PCs) have made provision for H&S costs in their tenders;
- provide PCs with any information that might affect H&S, and
- ensure that sufficient H&S information and resources are available to the PC where changes to the design or construction are made.

Many of the requirements relative to clients implicitly require project manager, designer, and quantity surveyor contributions, inter alia, preparing H&S specifications and providing information relative to H&S, and therefore consideration for / reference to H&S.

Procurement related issues
Procurement systems are important as they affect contractual relationships, the development of mutual goals, the allocation of risk, and ultimately provide the framework within which projects are executed (Dreger, 1996). The traditional construction procurement system which entails, inter alia, the engagement of a contractor through competitive bidding, invariably on the basis of lowest price, does not complement H&S (Rwelamila and Smallwood, 1999). Market conditions in South Africa are such that contractors frequently find themselves in the iniquitous position that should they make the requisite allowances for H&S, they run the risk of losing a bid or negotiations to a less committed competitor. During research conducted in South Africa approximately 50% of project managers advocated the inclusion of a provisional sum for H&S (Smallwood, 1996). This would ensure that all bidders allocate an equitable amount of resources to H&S.

South African contract documentation generally does not engender H&S. Although references are made to H&S in standard contract documentation, such references are primarily in the form of specific reference to the Occupational Health and Safety Act. In many cases they can be described as indirect, hardly coercive and, depending upon the level of commitment, contractors continue to address H&S to varying degrees (Smallwood and Rwelamila, 1996).

Project duration also impacts on H&S. A shortened contract period may result in a project duration that is incompatible with the nature and scope of the work to be executed (Hinze, 1997). Hinze (1997) also cites pressure to meet unrealistic deadlines as a common source of mental diversion which diversion increases the susceptibility of injury.

Pre-qualification of general contractors and subcontractors on H&S by clients and general contractors respectively, is advocated by Levitt and Samelson (1993). The purpose is to provide a standardized method for the selection of contractors on the basis of demonstrated safe work records, H&S commitment and knowledge, and the ability to work in a healthy and safe manner. This will ensure that only H&S conscious contractors are selected.

Importance of H&S
Table 1 indicates the importance attached to traditional and non-traditional project parameters to architectural practices in terms of percentages relative to importance on a

scale of 1 (not) to 5 (very), and a ranking based upon an importance index (II) value, ranging between a minimum of 0.00 and 4.00. It should be noted that these findings emanate from a study conducted in 1999, four years prior to the promulgation of the Construction Regulations (Smallwood, 2000). It is significant that project H&S, the subject of the study was ranked 5th, and that the three traditional project parameters in the form of quality, cost, and time, achieved rankings in the top three. Given that public H&S achieved an II value 0.62 higher than that of project H&S, it can effectively deemed to be perceived to be 23.7% more important, which was probably attributable to the relevance public H&S in the use of buildings.

Table 1: Importance of various project parameters to architectural practices (Smallwood, 2000)

Parameter	Response (%) Not ……………………………………………. Very					II	Rank
	1	2	3	4	5		
Project quality	0.0	0.0	1.9	7.7	90.4	3.88	1
Project cost	1.0	1.0	4.8	22.1	71.2	3.62	2
Project time	0.0	0.0	5.8	35.6	58.7	3.53	3
Public H&S	0.0	4.8	16.3	28.8	50.0	3.24	4
Project health and safety	4.9	12.6	20.4	39.8	22.3	2.62	5

Impact of legislation

Brabazon, Tipping, and Jones (2000) conducted research in the United Kingdom to investigate inter alia, the impact of The Construction (Design and Management) (CDM) Regulations on H&S performance. They determined that the CDM Regulations promulgated in 1994 had probably been successful in reducing fatalities on construction projects, but that there were still areas where improvements could be made. From the analysis of the data from the five years 1993/4 to 1997/8, it was concluded that the overall number and rate of fatalities had decreased slightly by 10% since the introduction of the CDM Regulations.

A further study conducted in the north of England by the Health & Safety Executive (HSE) entailed the assessment of designer performance in six key areas (Charnock, 2004). The study was intended to review developments relative to designer construction H&S related practices since the prior study conducted in 2003. Selected findings were: 60 % of designers were assessed as having good or adequate knowledge of their responsibilities in terms of legislation; 51% of visits indicated that design practices' policies and procedures for ensuring that risk reduction is integrated into the design process is good or adequate; 50% of design risk assessments and associated documents used to provide an auditable trail of the design actions were assessed as poor or limited; 62% of designers were judged to have adequately succeeded in minimising the risks associated with work at height during construction and maintenance, and 52% of designers were judged to be effectively communicating design information to other parties. Overall 56% of designers achieved a rating of good or adequate. The research conducted by Brabazon, Tipping, and Jones (2000) identified opportunities to improve construction H&S in seven areas, 'H&S by design' included.

RESEARCH

Sample stratum and response

The sample stratum consisted of all 1 050 practices registered with the South African Institute of Architects (SAIA). 34 Questionnaires were not delivered to addressees, and were returned to the sender. 87 Questionnaires were included in the analysis of the data, which constitutes a net response rate of 8.6% [87 / (1 050 – 34)].

Analysis

The analysis of the data consisted of the calculation of descriptive statistics to depict the frequency distribution and central tendency of responses to fixed response questions to determine the degree of importance of various parameters.

Findings

97.7% of respondents indicated that architectural practices represented the business entity which best categorised their organization? Table 2 indicates the importance of five parameters in terms of percentage responses to a range of 1 (not important) to 5 (very important), and in terms of a mean score ranging between 1 and 5. It is notable that the mean scores are all above the midpoint score of 3.00, which indicates that in general the respondents can be deemed to perceive the parameters as important. However, given that the mean scores for the top three parameters are $> 4.20 \leq 5.00$, the respondents can be deemed to perceive them to be between more than important to very important / very important. Given that the mean scores for the environment and H&S are $> 3.40 \leq 4.20$, the respondents can be deemed to perceive them to be between important to more than important / more than important. It is significant that the traditional project parameters (quality, cost and time) are ranked in the first three. Furthermore, it is notable that the subject of the study, H&S, has a mean score 1.21 below that of first ranked project quality – project quality is effectively 49.8% more important than H&S. However, it is significant that the importance of project H&S has effectively decreased by 5.2% from 3.62 (2.62 on a range from 0.0 to 4.0) in 1999 (Smallwood, 2000), to 3.43 (on a range from 1.0 to 5.0) in 2005.

Table 2: Degree of importance of various parameters to respondents' organizations

Parameter	Response (%)						Mean score	Rank
	Unsure	Not ……………………………… Very						
		1	2	3	4	5		
Project quality	1.1	1.1	2.3	1.1	16.1	78.2	4.64	1
Project cost	1.1	0.0	3.4	10.3	24.1	60.9	4.39	2
Project time	1.1	2.3	2.3	14.9	23.0	56.3	4.25	3
Environment	2.3	1.2	5.8	17.4	30.2	43.0	4.01	4
Project H&S	12.8	3.5	8.1	15.1	24.4	36.0	3.43	5

Table 3 indicates that approximately the majority of respondents are aware of the Construction Regulations. However, nearly a quarter was unsure.

Table 3: Awareness of the Construction Regulations

Response	%
Yes	67.8
No	8.0
Unsure	24.1

Table 4: Project stakeholders affected by the Construction Regulations

Response	%
Clients	94.1
Contractors	94.1
Architects	91.2
Project managers	86.8
Engineers	83.8
Subcontractors	79.4
Quantity surveyors	61.8
Landscape architects	47.1
Materials manufacturers	45.6
Interior designers	44.1
Materials suppliers	41.2

The majority of respondents indicated that clients, contractors, architects, project managers, engineers, and subcontractors are affected by the Construction Regulations (Table 4). Approximately 62% indicated that quantity surveyors are, and less than 50% landscape architects, material manufacturers, interior designers, and materials suppliers. However, all the stakeholders presented in Table 4 are affected by the Construction Regulations. In terms of Regulation 'Structures' 9 (2) (d) designers are required to "Modify the design or make use of substitute materials where the design necessitates the use of dangerous structural or other procedures, or materials hazardous to H&S." Further, the definition of designer includes surveyors specifying articles or drawing up specifications, interior designers, shop-fitters,and landscape architects.

Table 5 indicates the impact of the Construction Regulations in terms of percentage responses to 'no impact' and a range of 1 (minor) to 5 (major), and in terms of a mean score ranging between 0 and 5. Given that effectively a six-point scale ('no impact' linked to a five-point) was used and that the difference between 0 and 5 is five, ranges with an extent of 0.83 (5 / 6) are used to discuss the degree of central tendency. The ranges relative to the mean score categories are:

- $> 3.33 \leq 4.17$ - between an impact to near major impact/near major impact;
- $> 2.50 \leq 3.33$ - between a near minor impact to impact/impact, and
- $> 1.67 \leq 2.50$ - between a minor impact to near minor impact/near minor impact

It is notable that the mean scores for thirteen of the sixteen manifestations are above the midpoint score of 2.50, which indicates that in general the related manifestations can be deemed to be prevalent.

The manifestations falling within the higher range of mean scores > 3.33 ≤ 4.17 - between an impact to near major impact / near major impact, are discussed first.

Increased H&S awareness, followed by increased consideration for / reference to H&S by general contractors, and by project managers, predominates. Increased H&S awareness is a significant manifestation, as awareness is a pre-requisite for commitment and the allocation of resources. Increased consideration for / reference to H&S by project managers is also a significant manifestation as project managers in their capacity as project leaders and coordinators, are uniquely positioned to integrate H&S into projects, in particular the design and development, and construction phases (Smallwood, 1996; Hinze, 1997). Given that project managers coordinate design and / or design delivery, they can influence designers, and therefore increased consideration for / reference to H&S by them is likely to result in increased consideration for / reference to H&S by designers. Further, it is notable that the latter manifestation is ranked ninth with a mean score of 2.94, which is 19.7% lower than that relative to increased consideration for / reference to H&S by project managers. The second range of manifestations, those with mean scores > 3.33 ≤ 4.17 - between an impact to near major impact / near major impact, are discussed below.

Increased consideration for / reference to H&S by subcontractors is ranked fourth, whereas increased consideration for / reference to H&S by general contractors is ranked second. However, on the scale of 0 to 5, the latter mean score of 3.70 is 12.9% higher the former of 3.17. Fifth ranked review of provision for H&S - other e.g. H&S plan, programme is ranked higher than review of financial provision, which is ranked joint sixth with improvement in H&S. The latter is followed very closely by improvement in H&S, increased consideration for / reference to H&S by designers, and improved conditions on site.

Table 5: Manifestation of the impact of the Construction Regulations

Aspect	Response (%)							II	Rank
	Unsure	No impact	Minor …………………………… Major						
			1	2	3	4	5		
Increased H&S awareness	8.3	1.7	1.7	10.0	18.3	33.3	26.7	3.75	1
Increased consideration for / reference to H&S by general contractors	7.4	2.9	2.9	10.3	23.5	16.2	36.8	3.70	2
Increased consideration for / reference to H&S by project managers	9.0	1.5	3.0	14.9	13.4	31.3	26.9	3.66	3
Increased consideration for / reference to H&S by subcontractors	7.4	2.9	8.8	19.1	23.5	14.7	23.5	3.17	4
Review of provision for H&S - other e.g. H&S plan, programme	16.7	1.5	12.1	10.6	22.7	19.7	16.7	3.16	5
Review of provision for H&S - financial	14.7	5.9	7.4	13.2	25.0	19.1	14.7	3.03	6=
Improvement in H&S	5.9	2.9	10.3	13.2	33.8	22.1	11.8	3.03	6=
Improved conditions on site	5.8	4.3	11.6	14.5	27.5	23.2	13.0	2.98	8
Increased consideration for / reference to H&S by designers	4.5	6.0	11.9	20.9	19.4	17.9	19.4	2.94	9
Reduction in accidents	27.3	6.1	9.1	10.6	19.7	13.6	13.6	2.92	10
Increased consideration for / reference to H&S	10.8	6.2	9.2	20.0	30.8	13.8	9.2	2.72	11

by quantity surveyors									
Review of forms of contract	18.8	8.7	7.2	17.4	20.3	21.7	5.8	2.70	12
Change in work practices	8.7	8.7	11.6	23.2	23.2	14.5	10.1	2.59	13
More structured / deliberated approach to work	10.3	8.8	11.8	27.9	20.6	14.7	5.9	2.43	14
Review of procurement practices	24.6	8.7	10.1	17.4	24.6	13.0	1.4	2.37	15
Prequalification on H&S	19.7	16.7	12.1	10.6	16.7	18.2	6.1	2.32	16

Eleventh ranked increased consideration for / reference to H&S by quantity surveyors is followed closely by
review of forms of contract. The mean score of the latter is notable in that the standard forms of contract in South Africa do not make adequate reference to H&S. However, the manifestation is prevalent, which indicates that the Construction Regulations have had an impact. Change in work practices is ranked thirteenth, its mean score marginally above that of more structured / deliberated approach to work.

However, the mean score for more structured / deliberated approach to work is > 1.67 ≤ 2.50 - between a minor impact to near minor impact / near minor impact. Review of procurement practices and pre-qualification on H&S also occur in this range. These are notable findings as the Construction Regulations explicitly and implicitly require a range of procurement related interventions. Furthermore, procurement can impact on inter alia, H&S, either positively or negatively. The Construction Regulations also require the client to ensure that the PC has made adequate financial allowance for H&S. This and other requirements explicitly and implicitly require that the PC and SCs be pre-qualified on H&S.

Table 6 indicates that the respondents perceive that the Construction Regulations will have between: an impact to near major / near major impact on H&S; a near minor impact to impact / impact on time, cost , and the environment, and a minor to near minor impact / near minor impact on quality.

Table 6: Extent to which the Construction Regulations will impact on various project parameters

Parameter	Response (%)						II	Rank
	Unsure	Minor …………………………………… Major						
		1	2	3	4	5		
Project H&S	17.6	7.1	2.4	16.5	21.2	35.3	3.91	1
Project time	17.6	10.6	11.8	27.1	20.0	12.9	3.16	2
Project cost	16.5	12.9	10.6	27.1	22.4	10.6	3.08	3
Environment	22.4	22.4	10.6	18.8	22.4	3.5	2.67	4
Project quality	17.6	27.1	7.1	29.4	12.9	5.9	2.56	5

CONCLUSIONS AND RECOMMENDATIONS

The importance of various project parameters

Despite the promulgation and implications of the Construction Regulations, the traditional project parameters in the form of cost, quality, and time are still perceived to be substantially more important than H&S.

This conclusion amplifies the need for architectural practices to make a paradigm shift in terms of the status of H&S. Furthermore, the SAIA should engender such a paradigm shift through: the requirement that H&S be addressed in architectural programmes, and the provision of H&S related practice notes and guidelines.

The manifestation of the impact of the Construction Regulations

Generally, the Construction Regulations are perceived to have had an impact. The manifestations of the impact are wide spread, which was the intention of the Construction Regulations. Increased H&S awareness predominates among the manifestations, followed by increased consideration for H&S by all stakeholders, in particular. These are important manifestations as they occur 'upstream' and are necessary to influence the downstream process. Increased provision for H&S, both financial and other, and review of forms of contract are important 'midstream' manifestations as they also influence the downstream process. Improvement in H&S, improved conditions on site, and reduction in accidents are all significant and 'downstream' manifestations. Consequently, it can be concluded that the Construction Regulations have had the desired 'upstream', 'midstream', and 'downstream' impact.

The mean score relative to increased consideration for / reference to H&S by designers reinforces the recommendation that architectural practices should make a paradigm shift in terms of the status of H&S, and that the SAIA should engender such a paradigm shift.

The extent to which the Construction Regulations will impact on various project parameters

The findings in the form of the perceived extent to which the Construction Regulations will impact on various project parameters justifies the promulgation thereof, particularly relative to H&S, but to a lesser extent, time and cost, and also the environment, and quality.

Recommendations include that H&S be addressed in architectural programmes, and that the SAIA provide H&S related practice notes and guidelines, which address the synergy between H&S and the other project parameters.

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THE CONSTRUCTION INDUSTRY TAKES UP THE GAUNTLET

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Abstract
Public and political dissatisfaction with the Danish construction industry in terms of low productivity, high prices and poor quality has lead the industry to a stage where new methods and new innovative measures are needed. The industry, supported by the government, has engaged in a range of experiments in the last decade. Many of these results are now being implemented in daily production. Special focus has been on new management concepts and activities to improve the general image, not least to signal the drive for better quality and value and to attract a new generation of workers. Increased focus on health and safety, including attempts to reduce the high risks of accidents in the industry has also been addressed. This paper questions whether these activities are enough and presents an ongoing research project that illustrates the need for innovation from a more holistic, normative and learning perspective.

Keywords: Management concepts, safety culture and learning, working environment.

INTRODUCTION

The Danish construction industry has for the past decade been faced with public demands to increase productivity and to improve its image (Byggepolitisk Task Force, 2000). The industry has responded and taken on a range of activities such as new managements concepts and has put more emphasis on working environment activities. This paper discusses some of the changes in terms of communication, roles and the working environment.

The number of people employed in the Danish construction industry is approximately 6 % of the total number employed in Denmark. The industry is very much a home based industry; export is primarily seen in the building material sector. The new-build sector employs approximately 1/3 of the workforce in the industry and the repair and maintenance sector a little under half of the workforce (Byggepolitisk Task Force, 2000). Costs have been steadily increasing. Compared with the costs in 1987 the total cost has increased by 54% up to 2000. The cost of materials in this period has increased by 52% and the cost of salaries by 62% (BAT, 2001). The division of trades is still very traditional in the industry and usually related to the types of materials used, for instance wood for the carpenters, concrete for the concreters etc., however, a spread of activities and trades can be seen through sales and fusions of firms, either offering similar services or in the capacity of being the special providers of building materials.

The level of education and professional training is high. The trade training is between 3-3½ years long, organized in alternating sequences between a firm and a technical school. At present there is an anxiety about whether the industry will experience a downfall in the number of young workers. General employment conditions, including the working environmental are negotiated in tripartite cooperation, consisting of the employer's organisations, the unions and the state. This also happens regionally to support project related negotiations of education, work and wages. Usually work is measured as piece rates. Union participation is high, between 80-85%.

The Danish Working Environment Act applies to all work performed for an employer (The Ministry of Employment, 2005). The central part of the act is an extended safety and health concept, which means that all factors causing accidents, sickness and attrition must be taken into consideration in the preventive work. It is the responsibility of the employer to ensure that the working conditions are safe and sound in any way and that the employees receive the proper instruction to be able to perform the work. The employees on their part are obliged to participate and cooperate on issues on health and safety, including the use of protective equipment. The Danish Working Environment Authority supervises whether acts and rules in specific industries are observed through inspections visits and direct guidance of the firms and their safety organizations for the overall goal of enabling the firms themselves to solve tasks in relation to health and safety (www.bar-ba.dk). According to size and type of work the daily health and safety work is organized through the safety organization, which always comprises representatives from both employer and employees. In construction a safety organization also must be set up for temporary workplaces such as construction sites. Special rules apply to this setting.

"DOUBLE THE QUALITY FOR HALF THE PRICE"

The demand for improvements in the construction industry, such as higher quality of output, an improvement in the working environment in general and specifically in relation to accident prevention was formulated in a white paper by a Building Political task force formed by the Ministry for Towns and Housing and the Ministry for Industry in the late 1990s. The white paper was developed from rising public and political criticism of the construction industry and influenced by The Egan Report *Rethinking Construction* (Byggepolitisk Task Force, 2000, Egan 1998).

"Double the quality for half the price" was the ambitious slogan of the Danish Minister of Housing in the mid 1990s. By this she summed up what she, and others, saw at the key problem of the construction industry. The white paper and other reports analysed and validated this viewpoint and pointed at a range of special issues that needed to be addressed in order to introduce radical and profitable changes in the industry. In the following decade a wide range of experiments in relation to the use of materials, cooperation, and organisation of work took place, supported by public funding. Presently the industry is in the process of taking in the better part of the results of the experiments, especially new management concepts and new approaches to health and safety being implemented in daily production (Bertelsen, 2002).

In the same period The Danish Working Environment Council launched a programme called Clean Working Environment 2005 in which they focused on seven vision areas. These were fatal and serious accidents, work related brain damage due to use of chemical substances, prevention of work injuries to adolescents, heavy lifting and monotonous repetitive work, psychosocial risk factors, poor indoor climate and finally noise in the workplace. Indicators in the respective areas were established through research and implemented through adjustments in the rules and through awareness campaigns (www.bar-ba.dk).

NEW UNDERSTANDINGS OF MANAGEMENT

Three management concepts seem to be in focus and/or meeting the need for positive improvements in the production process, value management, partnering and lean production. More specifically:

- Value management touches ethical issues in production and implies a commitment to certain moral based values. Many big construction firms have formulated ethical statements for their business and use these to signal a definite profile to clients, to the public and to their employees.
- Partnering is based on an economical openness between firms/partners. Project partnering and/or strategic partnering can be more or less formal, but is mostly used by firms that provide the design and planning services in the building process.
- Lean production addresses value creation through changing the production flow. It consists of tools to minimize waste, managing the flow of work by focusing on previous work made, space, crew, equipment, information, materials and external conditions ("the 7 streams"), and a Last Planner system, which includes meeting and dialog with foremen and gang leaders on working activities ahead on a weekly basis.

These management concepts all implements changes from a top-down perspective and are thus the tools applied by managers with a professional background and training in engineering or in architecture.

WORKING ENVIRONMENT

The working environment area has a bottom up approach, specifically defined in the working environment law's overall objective. As mentioned before it is the firms themselves that have to carry out the work safety in cooperation with the employees and with the support of the social partners and the state (Ministry of Employment, 2005). In recent years, however, an increased focus on working environmental changes in the construction industry has especially been centred on the role of the client. The client is legally responsible for the working environment during production (Bertelsen, Fuhr & Davidsen, 2002). This includes producing a plan for health and safety, carrying out risk and work assessments for the work to be done, setting up a safety organisation and setting aside a suitable amount of resources to allow the working environment on the project carried out according to the law (as a minimum). The client is required to hire a consultant to undertake this job.

The occurrence of accidents in construction (8%) is high compared to the combined average of other industries (6%). Accidents are expensive both in human suffering and in economical terms. Costs in relation to different types of accidents have been laid down to prompt the client/employer to increase investments in preventive measures. Despite introduction of a rage of measures to reduce the number this seems to stay more or less on the same level. There is, however, one remarkable exception. One of the biggest Danish construction firms has reduced accident rates through the application of the Lean Production concept (Thomassen, 2002). The key to this seems to be the Last Planner system and the weekly meeting with the foremen and gang leaders. Other preventive measures in safety work in the industry include tools such as bench marking, risk assessments, inspection rounds by the safety organisation ('mønsterarbejdspladsen') and the use of working environment consultants. Also on industry level the level of safety set by the working environmental law at any given time is complemented by levels of best practice often in the form of written materials, which the social partners produce together (www.bar-ba.dk). The on-going work on work environmental issues in general both in the firms and on the sites is predominantly seen as the responsibility of the safety organisation. The law defines the safety organisation's composition and role to be democratic and to have influence on the planning and execution of the work. The safety organisation's work on site is, however, often hampered by the fact that many safety issues are interlinked with decisions taken in other forums. This is for instance often the case in decisions taken at a building meeting where the site manager meets with the subcontractors and discusses planning of time and cost of ongoing operations. Thus often decisions taken in these forum subordinate decisions taken at the safety meeting, where the participating members for one thing are not the same. Another reason for low influence and priority at the safety organisation relates to the irregular presence of certain trades on sites, and finally insufficient training and appropriate skills in health and safety steps.

MEETING AT THE BATTLEFIELD

Innovative changes in the construction industry arise primarily from two main sources, a top down approach introduced by new management concepts and a bottom up approach through increased focus on the working environment, accident prevention and general health prevention. The question is where do these two approaches meet? Do they interact well and complement each other or contradict each other? Do they introduce new roles and/or new communication routes?

Looking at the traditional production flow in the construction process, management and working environment meet all the time in the daily activities on site. The process leading up to the work on site is usually described as an unbroken line or as a transformation/flow/value process (Bertelsen, 2004), which goes from client wishes, over specified blueprint by an architect, to technical calculations by the engineer. In an ordered system this is carried through by transformation of professional skills and competences and presented in a written form. After tender the material is handed over to the contractor whose task is to transform the written outlines into working orders for the subcontractors - a transformation that demands distinct communicative abilities in the work setting and which is dominated by verbal communication. The main contractor is responsible for the safety on site by establishing the infrastructure, roads, lights etc. The subcontractor is responsible for health and safety in organizing his own contract and carrying out the work. Coordination between contractors happens at 'building meetings' and in relation to health and safety at "safety meetings'.

This creates in practice two different systems, one defined as a top-down managerial system and the other as a bottom-up elected representative system, which gives fuel to the need for creating balance between them or more precisely to have them integrated. (Bertelsen, 2004) In a critical sense the two different systems can be understood as two systems of organisation that runs parallel on site. Where the one system operates basically as a strict hierarchical line of responsibility and order giving, i.e. the building meeting and the other system the safety meeting is aiming toward improved negotiation and a more democratic dialog.

Fundamentally the two systems are based on two different ontological understandings. Where the one system reflects a general understanding in the industry that what is needed to make work proceed is firm decision-making and behaviouristic manners by the management. Often described in terms of use of incitements such as punishment and rewards – fines and bonus'. The other system represents a more democratic and humane approach to decision-making and illustrates the diversity upon which the safety organisation is based. Despite changes ongoing investigations confirm that a common understanding among operators still is that important decisions are taken at the building meeting and that the safety meeting has a low priority (Davidsen, 2005). Another common understanding is that the middle management (who could be the subcontractor or foreman or gang-leader) is considered to be the weak point in terms of inefficient communication and carry-over of the site manager's orders to the operators. This is, however, somewhat contradicted by the experiences of using Lean Construction. Both systems approaches acknowledge, however, that the building process is complex and dynamic through the sharing of resources, competitiveness and the 'one of a kind' situation, despite especially small and medium sized contractors often feel an operational conflict between the two systems.

Strategies to optimise the construction process suggest reducing the complexity of the building process. This could lead to an increase in off-site manufacturing and more insitu assembly work or outsourcing (Byggepolitisk Task Force, 2000). Another strategy suggested is to improve the transfer of experiences and knowledge through the whole planning and production phase. The Last Planner System in the Lean production concept can be seen as one approach to this kind of management, transferring insights from both top management and middle management, on-going planning in split up sizes suitable for a five week operation period and a one-week logistics plan, also called 'look ahead planning' (Bertelsen, 2004).

This organisation is beneficial to the integration process between contractors and gang leaders. One reason for this may be that the middle management immediately recognizes the benefits of the short-term and rolling coordination, which allows them more precisely to integrate information in their own planning. The site manager often has a tendency to consider the Look ahead Plan as their own business, so by sharing information and having a dialog with the partners involved allows for closer integration of other subjects such as health and safety as well. A big Danish construction firm has for instance been able to reduce their accidents by 20% after the introduction of the Last Planner System (Thomassen, 2002). Looking at the success by using the Last Planner System has also raised some familiar criticism. On the one side middle management is taking on new roles by being more directly involved in the planning, however, this has not resulted in accommodating the operators' need for more precise knowledge and information. Middle management with a few exceptions is not able to communicate these decisions to the operators in a satisfactory manner (Bertelsen, 2004).

Where the new management principles improve the product quality with the improved flow of work, the traditional top down management is challenged with a bottom up responsibility in accordance with the use of Last Planner System. Addressing the complexity through dialog, cooperation at an involved level and shorter planning phases seems the way forward, however also calls for new skills and training in the disciplines mentioned to make it more optimal (Bertelsen, 2004). It also calls for a better understanding of the cultural aspects of change.

SAFETY CULTURE

The interest in understanding the cultural aspect in management can be seen as a counterbalance between a classical industrial understanding of management, and an approach of symbolic interaction and changes. This can also be seen as a way to begin to integrate the conflicting systems in the organisation. However, where the symbolic interaction underline a moderate interest in the individual and stresses the importance of general knowledge and learning in reflection with the surrounding elements in present time, the classical industrial understanding has a more contemporary frame of understanding only. A cultural understanding must enhance both community and multiplicity in the firm and operate with a relatively stable perspective, as well as the importance of development and maintenance of shared opinions in social groups (Alvesson, 2001).

Safety culture is a part of the organisational culture. There can be many cultures at the same time – within a culture. Safety culture can be defined as "the ideas and beliefs that all members of an organisation share about risk, accidents and ill health" (Richter & Pedersen, 2004). These ideas and beliefs are often shared by both employees and employers and founded in workplace experiences and workplace learning. Safety culture comprise two central elements, 'integrative' activities and 'differential' activities, both of which relate to values in the perception of work, in the understanding of risks, professional reputation, work autonomy, peer approval and work cooperation.

Construction firms have a strong element of entrepreneur culture, which tends to put interest in production above safety rules. However, another interacting tendency is what can be described as "the organised good will", which is a culture that wishes to "obey" safety rules, and laws and develop these into tools to prevent risks and accidents. It is often from these cultures that safety representatives and safety managers are recruited. Research has shown that apart from several safety cultures existing side by side in an organisation and on the construction site, a specific safety culture is related to the individual person irrespective of trade, function or position (Richter & Pedersen, 2004).

BYG-SOL -AN INTEGRATED APPROACH TO CHANGE

Cooperation and learning appear to be the keywords in the current changes in the Danish construction industry. This is also the name of yet another research project (BygSol) that is offering a new and interesting perspective on the building process. It is an on-going action research project, which addresses many of the highlighted problems. In contrast to other initiatives BygSol also tries to integrate and mix activities. BygSol operates with an approach that integrates Partnering and Lean Construction with a new practice of on-site workplace learning. The focus is on the area where top down meets bottom up (Walløe & Dam, 2005). 22 construction sites in Denmark participate directly and the educational system is also involved; represented by 5 technical schools involved in relation to the sites and three Universities in offering theoretical explanation and evaluation. Also the social partners the employer's organisation (Dansk Byggeri) and the employee's organisation (BAT) take an active interest in the activities.

The overall understanding is that "creation of knowledge must be understood as a social activity, in which new understandings are born, which makes new actions possible" (Walløe & Dam, 2005). Change/innovation and learning are two sides of the coin. On the one side it can be seen as external changes in work processes, organised strategies, practises and systems. On the other side it addresses an internal change in man's values, dreams, wishes and actions.

In relation to workplace learning BygSol defines it as interplay between management and employees and the organisations culture and structure. Where this interplay today is based in rational management thinking, BygSol underlines creation of a more humane and normative contexts and a holistic understanding in different contexts. This has in practice found a form where working environmental issues has been discussed in relation to "natural" production issues.

The theoretical learning model developed and used is based on Chris Agryris' (Agryris 1974) loop learning and Donald Schön's (Schön 1984) description of the reflective practitioner. BygSol focuses on learning as problem oriented, initiated from everyday situations arising. It is claimed that everyone has challenging and interesting activities in their job and there is a strong relation between the firms and its employee's need for innovation, competences and learning. Collective reflection is possible and necessary and finally that new cooperation between firms and the formal educational institutions will emerge and must be met. To summarise where BygSol seems to making groundbreaking changes in comparison with more traditional approaches:

- Communication is based to a higher degree on personal meetings and verbal dialog from the start when possible, otherwise when needed, throughout the entire process and includes all actors.
- Teambuilding between all actors involved in production from the start-up on site.
- Weekly meetings of one hour's length where all workers at the site are present.
- Coaching, rather than order giving, is implemented at meetings
- Integrated meetings in relation to ongoing planning, activities to come and health and safety.
- Learning and reflection rather than "punishment and reward"
- Increased focus on well being and solidarity
- Good atmosphere and appreciative communication
- Waste reduction through short decision making processes
- Increased awareness and cooperation between trades and a shared canteen.

Apart from being able to attract many progressive construction firms that want to be in the frontline, preliminary data shows that operators on the construction site see positive improvement; courteously expressed in their work situation by participating in BygSol activities (Walløe & Dam, 2005) or as expressed by a safety coordinator in one of the big firms "I don't really know what it is, but it works!" (Personal note, 2005). EU's Social Fund basically funds the project over a three-year period although the firms can only participate by paying for their employees, on a one to one basis. The project is currently in its mid phase.

CLOSING REMARKS

Whatever way one looks at the situation in the Danish construction industry changes must take place to make it both competitive and an attractive place to work. Many activities are taking place, many ideas are being tried but the challenge of "double the quality for half the price" is still on, and there are new challenges. The enlargement of the European Union in 2004 has led workers from other countries, not least the East European Countries, to come and work in the Danish construction industry. The social partners want this to happen only on equal terms with Danish workers and by recognising a safe working environment. This also puts pressure on the Danish construction industry in its exploration of new innovation, production methods and cooperation by the social partners. The new innovative methods presented here have resulted in improvements in communication, the development of new roles and a new working environment. Another conclusion is that the Danish construction industry must strive even harder to be more innovative, be able to give the client a better product, be more appealing to a younger and a well qualified workforce and be able to ensure ongoing learning and updated competences for all actors. The industry must apply more holistic methods similar to the one BygSol offers, but other ways may be equally applicable. The floor is open.

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MANAGING ARCHITECTURAL DESIGN BY RULES OF THUMB

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Abstract
Meeting daily with innovations in the field of construction management, as integration, optimisation, efficiency, creativity, is an every day event. Nevertheless, a lack of *valuable architecture*[1] is still an evident problem. Management methods or strategies focus architectural design processes generally, but we require specific management methods including responsibility, which can concentrate on a healthy, user-orientated, environmentally sound, or greener architecture. Hence, we are aiming for an easy and transparent management help, preferably in the form of guidelines, rules, and tools. There are already theoretical resources available for improving and applying such instruments. Some researches, including PhD studies, gained such means at the Eindhoven University of Technology. Those results will be discussed in this paper. Architectural design has a high degree of complexity. It is dependant on the contribution of a number of design experts, as well as users. Because of this intention, it has to be teamwork. A proven working method, the Method Holistic Participation, can help to manage a *valuable architectural* design within a short time. The most important aspect is to search for consensus for decision-making in the light of a whole life approach between all participants[2]. Furthermore there are steps formulated leading to higher value in architectural design. Those rules of thumb are based on the author's previous experiences, realising *valuable architecture* in a small scale. We see practical possibilities and challenging opportunities for further improvement of nowadays-architectural design processes. At the same time, we search for concrete possibilities for reconnecting architecture to elementary life values. In addition, the paper deals with culturally and socially relevant factors as well.

Keywords: Architectural value, ecological factors, human factors, rules of thumb, teamwork.

INTRODUCTION / BACKGROUND

The usual way of executing architectural design and building realization processes, except in cases of huge projects, has not included architectural management - in its nowadays-specialized form. In the last decades, management strategies took an enormous booming. A "big job" came into existence and many different management styles have already developed, which very roughly could be categorized by the range from 'no-nonsense' to 'spiritual', and from 'to the point' to 'fully user-orientated' or from 'sophisticated' to 'holistically', etc. In the past, it was already necessary to manage carefully all steps to get something complex done in the building sphere. In those days, we did not speak about management, but organization. At the same time, there where no specialized educational programs available. Organization mostly was a question of talent, experience, and good luck.

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[1] The authors understand under *valuable architecture* an architecture, which fulfils users need without health risks, which has minimal environmental impact, which optimize technical possibilities, and which expresses harmony at the same time.

[2] All participants who are collaborating in the building process and maintaining process.

Figure 1
Architectural value, logo of management for quality of life

In spite of a fast development in the field of architectural design, we still lack proper and practically applicable methods and strategies for organizing *valuable architectural* design processes. There are only coincidental cases, which answer the expectations for a clear integral architectural management. A management approach, like at the Maharishi University of Management, can give very fruitful inspirations for best practice. In one hand, we seek for new guidelines and rules, at least for some rules of thumbs to rationalize architectural design processes on a transparent way. In the other hand, there is an urgent need to redefining architectural values. Since architecture is a reflection of many cultural phenomena, most probably it will take quite a time, before renewed values will be found, accepted, and implemented. Nevertheless, to include vital quality criteria for values with a high common sense into our management strategies, could be a good idea. It will also enlarge both the quantity and quality of all collaboration and co-operation processes in an architectural design. In our paper, we give some rules of thumb for a general management process and some further steps towards *valuable architecture*, trying to help managers to find their own responsible approach.

RULES OF THUMB

A transparent tool helps to work easy. Good rules of thumb are concise. Here we collected the once which answer the need for integration, optimization, efficiency, creativity, pleasure, as well as are suitable for *valuable architecture*, like healthy, user-orientated and environmentally-sound, greener building. Beside the most refined automatic assessment technologies as for example "eco-efficiency assessment" (Tucker *et. al.,* 2003), still uncomplicated rules have their place and fundamental meaning. Because of clearness, simplicity has a power to reach easy our consciousness and increase a higher level of personal responsibility, what can be used later even in very complex processes.

Eleven steps to higher value in architectural design

Eleven steps are provided to a general management approach in architectural design towards better health of humans and human's environment:

1. Location, Orientation
Choose a site, which will be healthy for its dwellers and inhabitants; consider the best possible orientation for the whole building as well as for all rooms;

2. Space, Mass
Shape useful, closed or open, protecting spaces; Include identity and expression in all large and small building masses and parts;

3. Modular Co-ordination
Apply harmonious and ergonomic measures in numbers, dimensions, weights, co-ordinated and meaningful;

4. Indoor Climate, Furnishing, Installation
Create a cosy and comfortable indoor climate with a minimum of installations and use flexible equipment and furnishing for a suitable atmosphere;

5. Structure, Construction
Design sheltering, load-bearing structures and simple, understandable, durable constructions, which do not make us dependant from much technical means;

6. Material, Energy
Use mainly renewable, endless available, growing, and re-usable, soft, clean building material, and similarly energy for production and exploitation;

7. Production, Building Process
Produce in a human way and by a healthy method; make a wise choice using handicraft or industry, self-help or automation; apply participation;

8. The Art of Joining
Detail, join, connect, and compose the 'nuclei' for all building parts and components in a harmonious manner, rather solid, but demountable, simple, efficient;
the nuclei or details determine the whole;

9. Use
Optimize the functions towards the best possible use;

10. Ecological Factors
A simple EIA – Environmental Impact Assessment can help to clarify the environmental quality of a design;

11. Human Factors
A simple HIA – Health Impact Assessment can help to clarify the health quality of a design;

How to construct sufficient design processes and reach adequate results?
There are two instruments offered in Figure 2, which can be used in both research and design:

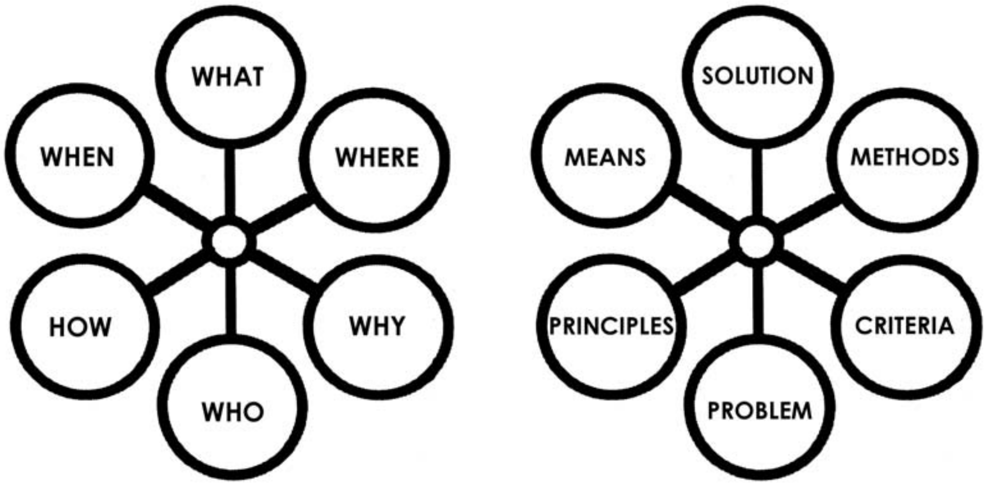

Figure 2
The instrument, shown at the left hand side, is the palette of topic questions, which if answered concerning a certain problem or task, delivers already a well-built part of the solution. The topic questions help to understand a total design approach.
The instrument, shown at the right hand side, is the star of relevant items related to any scientific, building-technological, or architectural problem. It could be seen in a broader cultural context, as well, or as a table of content within a PhD research study. The secret is the scientific description of each item, not reliant on their technological or even artistic aspect.

How to reach quick consensus with all participants in a design process?
Former cultures knew already consultation as a mean to solve their problems of survival. Since architectural design has a high degree of complexity, it has to be a collaborative and participatory process or in other words – teamwork. Finally, a good design is dependent on the contribution of a number of (design) experts, and, last but not least, of users and clients.

The Method Holistic Participation – MHP, which in a way was re-introduced by Konrad Wachsmann and Walter Gropius around the middle of the last century (and further developed and continued by the author), is an excellent working method, which can help to fulfil systematically most of the needs, criteria, and aims, as mentioned above.

One of the most important aspects within the given theme is to search for consensus for decision-making in the light of a whole life approach between all participants of a design process. MHP is also for this purpose a skilful, operational instrument. The new sociocratic approach (See Ref. 18.) with its management skills confirms those ideas. Nowadays the term mediation came into fashion. Mediation, likewise management, is actually not new. Consultation has already a long tradition, which goes far back to probably even so-called pre-historian periods of human cultures. Consultation with its own typical rules can be seen as a form of mediation. The change of the different - sometimes-opposing - viewpoints amongst the participants makes the impossible often possible when played in a role game.

Figure 3
Consultation, mediation, participation towards new values in architecture; schema shows the integration of (here three) components by a "role game" of designers, experts, users.

Figure 4
The MHP logo, showing the simplified weaving lines of the role game leading from a complex task via creative study and consultation or mediation towards a balanced and optimized result

MHP is a typical management tool and uses in its centre the method of consultation or mediation in order to build up an optimum of consensus within all participants for a successful common decision-making. MHP is a Planning and Design Decision Support System for cooperating persons or groups of people, all engaged or committed in a more or less commonly task for creating a design and consequently a building.
The various different aspects and/or factors and/or components of a complex problem, as a task for an architectural design, are rhythmically separately explored, and commonly discussed. After each informative and consultative plenum, the participants or groups of small teams go to change their aspect or factor or component in the next working session in order to get the necessary insight as well as influence, and to grow mutual understanding and consensus in the whole of the team. Even opposing opinions can be creatively optimized by the help of this method.

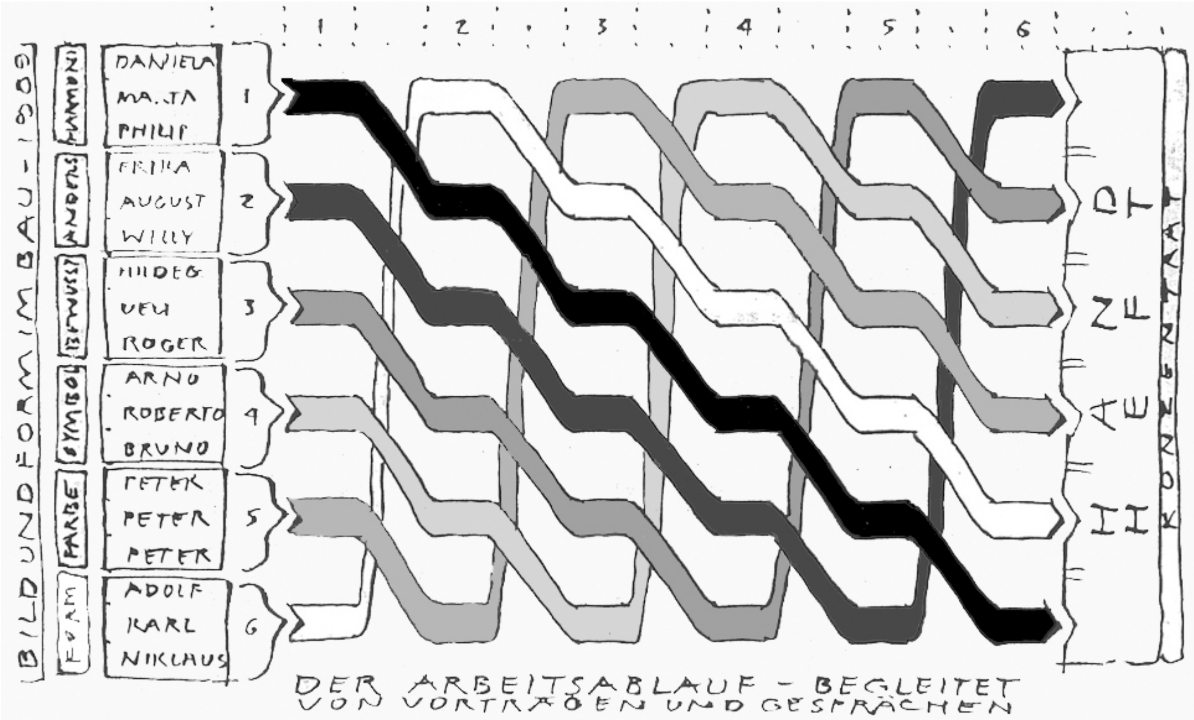

Figure 5
An example of a MHP working scheme, which can be adopted also for smaller or bigger groups, for shorter or longer periods, and for all types of complex tasks.

FUTURE DEVELOPMENT
We will need some idealism and power of realization to change today's attitudes and habits - within the usual architectural design and management practice - into a convinced aspiration regarding a sustainable, healthy, environmentally sound, and culturally stabilized built environment.

Many publications and international conferences deal with a fashionable environment and health-orientated approach. Very often, actually, it comes out that wellbeing, health, environment, sustainability are only keywords or slogans. A more fundamental approach to those world problems is mostly missing. Nevertheless, we have more chances to change our behaviour than ever before. The world has become 'smaller' by the tremendous possibilities of physical as well as information and knowledge connections. Humankind's consciousness is going to extend and to recognise itself as one family, which lives on one common planet – Our Earth - with its limited resources.

Architecture and building reflects the political and social circumstances of a civilization. There is the opportunity to achieve and to handle architecture and building as a responsible element within our world economy and world culture. It should get an exemplary and representative state, showing how fundamental values could be managed in consensus.

We briefly presented the need for re-defining architectural values and the requirement for co-operation within a design process. Our emphasis on integral design in architectural management is beyond question. This is the way to a sustainable development and finally to *valuable architecture*. Some rules of thumb, as an answer for those needs, were specified. Eleven steps to higher architectural values in design process were discussed. For the question "How to construct sufficient design processes and reach adequate results?" there are two instruments offered. Both are also beneficially applicable in education. More over, the Method Holistic Participation is warmly recommended. MHP realises an integral and 'whole life approach' design process, where consensus is a key element.

A fruitful architectural management has to integrate the actual and urgent needs of sustainability. This includes – holistically - health of humankind as well as environment, and a balanced economical situation in the whole world. Architecture and building, as major sectors within the world society, are not allowed to wait for comparable changes towards higher values in other sectors. They have to start or to continue with re-valuing architecture in their own responsible way. Then it will be possible to fulfil consumer needs, and to create environmentally conscious and healthy architecture, thus *valuable architecture*, as discussed in this paper.

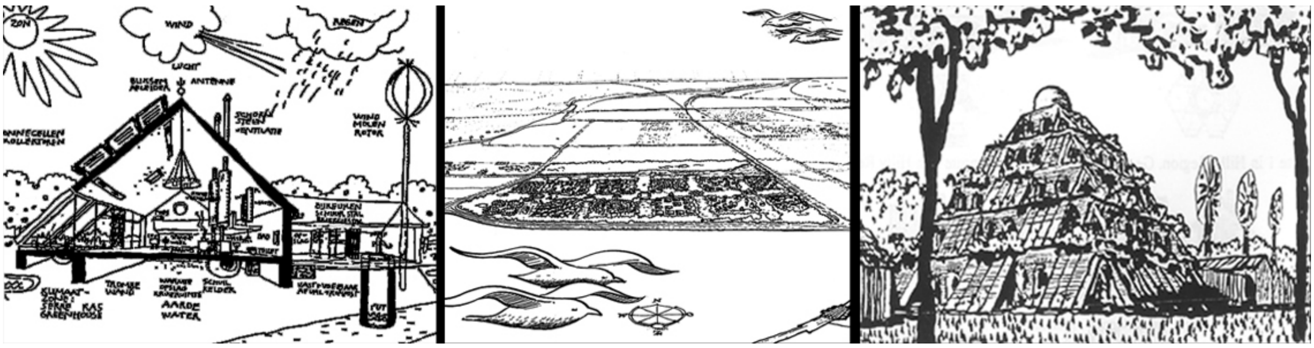

Figure 6
Collage of examples of MHP – managed designs and projects
Left: a building as an organism, joining all natural renewable resources;
Middle: a settlement design with 10 different districts, based on mixed functions;
Right: a multifunctional community building for sustainable life within a commune;

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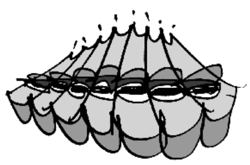

ARCHITECTURAL PRACTICE AND EDUCATION

KNOWLEDGE SHARING IN THE WILD
Building Stories' attempt to unlock the knowledge capital of architectural practice

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Abstract
Architects deal with unique projects, their knowledge is largely experience-based, tacit, and embedded within the design and construction process. Nevertheless, few consistent and systematic mechanisms exist that try to establish and maintain access to the profession's knowledge. Effectively capitalizing this knowledge thus seems as pressing a problem as producing more knowledge. Building Stories, an experimental course at UCBerkeley started with a carte blanche opportunity and generous support from leading architecture firms in the San Francisco Bay Area, to try and unlock the knowledge capital of architectural practice through storytelling. Five years later the paper looks back on how Building Stories has evolved into an inventive methodology for catalyzing knowledge sharing: between projects; between individual architects and architecture firms; and, finally, between practice and academia. After briefly recalling the underlying ideas of Building Stories and their implementation as an operational methodology, the paper reports on its recent in-depth evaluation involving former participants from various contexts: professionals in practice, students and researchers in academia. Besides valuable feedback on Building Stories as such, this assessment provides more general insights regarding current ideas and practices of knowledge production and sharing in architecture.

Keywords: architectural practice, collaborative culture, knowledge exchange.

INTRODUCTION
More and more people acknowledge that the activity of designing involves some kind of knowledge production. This directly follows from the type of knowledge designing relies on (Heylighen & Neuckermans 2000), which is largely tacit (Polanyi 1976) and embedded within the design process (Schön 1983). At the same time, the recent "academisation" of architecture is producing a growing body of knowledge, which hardly filters down to practicing architects (Neuckermans 2004). A survey among practitioners and academics in architecture revealed an evident lack of networking between both communities (Watson & Grondzik 1997). Doctoral dissertations, for instance, have become everyday food in most architecture schools, but their implications for professional practice, and ultimately for architecture as built environment, have yet to be demonstrated. Together these observations suggest that the challenge architecture is facing today should be seen less as a need to generate more knowledge than of making effective and equitable use of what is already available. In view of this, our research aims to develop a more profound understanding of the characteristics and roles of knowledge in architectural design, and to use this understanding as a basis for developing ideas about more efficient knowledge exchange between architectural practice and academia (Heylighen et al. 2005a).

CAPITALIZING ARCHITECTURAL KNOWLEDGE
Trying to improve knowledge exchange in architecture raises the question: what is knowledge in the first place? In the literature, knowledge appears as a concept with many facets and layered meanings. Rather than by formulating precise definitions, knowledge tends to be addressed by making all sorts of distinctions between different knowledge types, such as between declarative and procedural knowledge (Ryle 1949), or between explicit and tacit knowledge (Polanyi 1967). Tacit knowledge differs from explicit knowledge by the degree to which it can exist independently of a specific context or "knower". More in general, a distinction can be made between, on the one hand, traditional epistemology, which emphasizes the absolute, static, and a-

human character of knowledge and, on the other hand, the more recent theory of knowledge creation, which considers knowledge as a dynamic human process in which personal convictions are justified in search for the truth (Nonaka 1994). In the latter view, knowledge differs from information in that it only exists in the heads of people, whereas information exists outside the human mind and can be embedded in any attribute involved in communication (e.g. text, speech or images) (Coenen 2005). Sending information between people may cause change in the receiver's knowledge, i.e. lead to knowledge transfer. Yet, this transfer never produces an exact replica of the sender's knowledge in the receiver's mind, since the latter's memory is different when receiving the information and knowledge is precisely created by assimilating the information received in memory. Indeed, we understand by trying to integrate new things we encounter with what we already know (Schank 1982).

In a professional context, a similar distinction is made between, on the one hand, the "knowledge base", i.e. the formal and codified domain expertise claimed by a profession (Habraken 1997) and, on the other hand, the practitioner's "knowing-in-practice", which—as Donald Schön (1987) has taught us—is largely implicit and learned by doing. Medical doctors, for example, obviously must know about the human body, but if they are to diagnose an illness and cure the patient, this knowledge as such will not do. Similarly, lawyers must know more than the law it they want to apply it successfully in real-world cases.

Having more or less an idea of what types of knowledge exist, the second question to be addressed is: what (if anything) is specific about architectural knowledge? In other words, why do we think that architectural knowledge is special and thus needs a special treatment? According to Bryan Lawson (2004:6), a first clue that may help us answer this question is that design education looks different to much else of what goes on in universities around the world. If you go into schools of design, you will see time and again a very similar pattern grounded in the traditional master-apprentice model: students working in the design studio on limited, yet realistic design projects tutored by more experienced designers. The studio setting offers students an "espace transitoir" (Winnicot 1971) to real practice, where they learn through the practice of designing without being aware of what is learnt (Schön 1983, 1985).

In case of architecture, the commonness of the studio format should not come as a surprise. As Nicolaas Habraken (1997:267) points out: "*[o]f all the professional fields, architecture is where the virtue of a knowing-by-doing is most readily accepted by its practitioners.*" In fact, this exceptional cultivation of knowing-in-practice might point to a second clue: architecture's failure to claim a common knowledge base. In Habraken's view, the problem is not necessarily that architecture does not codify its knowledge base formally, as other professions such as law or medicine do: "*Granted implicitness, however, there should be some evidence that knowledge is shared among architects at all, because it is only by sharing that a professional knowledge base can be claimed*" (Habraken 1997:268). And this is where the shoe seems to pinch: the architectural profession not only tends to be highly secretive, it also fails to incorporate knowledge management theories and methodologies that have gained wide widespread acceptance in other fields (Doctors 2004). [1]

A third and final clue may be found in the innovation literature (that is, outside the architectural literature), which relatively recently complemented the classical distinctions mentioned above by distinguishing between component and architectural knowledge (Henderson & Clarke 1990). The latter term is introduced to denote "*knowledge about the way in which components are integrated and linked together into a coherent whole*." This reference to architecture seems to

[1] In fact, even the modest requirement of sharing a vocabulary is not met. As Habraken (1997:268) convincingly illustrates, architecture does not have a common language of general significance. Architects have an alarming tendency to coin a personal vocabulary and to give things new names every time.

derive from the fact that the different issues architects must take into account necessitate the continuous importation and integration of ideas from other disciplines to help guide the design process. Because architecture lacks a clear epistemological basis, the specificity of architectural knowledge thus seems to lie not so much in a particular set of ideas, themes, information, and theories, but rather in how these are worked through to produce architectural artifacts (Hoque 2004). In this view, the notion of knowledge is redefined as an active process, as a performative[2] rather than a static concept.

Given this intimate relationship between knowing and designing in architecture, it is perhaps not so surprising that, apart from a few pilot initiatives, there are hardly any consistent and systematic mechanisms to establish and maintain access to the profession's knowledge base, let alone to extend its potential reach.[3] Indeed, capturing and sharing something as complex and dynamic as architectural knowledge seems extremely difficult at first glance. (Some knowledge is recorded by the resulting construction documents or the built form itself (Habraken 1997:284), yet neither of both can reveal the constantly changing conditions that actually structure the process of designing (Brown & Duguid 1996).) This expectation, however, is not confirmed by every day life. People manage to cope with and share phenomena of very complex a nature fairly well. The natural way in which they seem to do so is by telling each other stories. A story is not only direct, easy to read and entertaining; it respects the intricate relatedness of things in a way that makes them easy to remember afterwards. As such, the story format provides a dense, compact way to deal with and communicate complexity in a short period of time.

There is neither need nor space to describe in detail how the mechanisms of storytelling work exactly, since this has been admirably done by Stephen Denning in *The Springboard* (2001). His own stories about the World Bank convincingly explain and at the same time demonstrate how knowledge can be transferred effectively by storytelling, not so much through transferring large amounts of information, but as a means to catalyze understanding. All that is necessary here is point out the applicability of stories to capture the wealth of knowledge and experience embedded in architectural practice, and to share and exchange it with others. To this end, the following sections zoom in on Building Stories, an attempt to unlock and explore the knowledge capital of architectural practice through storytelling. After briefly recalling the ideas underlying Building Stories and their implementation as an operational methodology, a recent in-depth evaluation involving former participants is reported on. Besides valuable feedback on Building Stories as such, this assessment provides more general insights regarding current ideas and practices of knowledge production and sharing in architecture.

BUILDING STORIES IN A NUTSHELL

Building Stories is a program developed at the University of California-Berkeley to capture and explore the tacit knowledge embedded in real-world building projects (Martin et al. 2003). Inspired by the power of storytelling as a vehicle for tacit-to-tacit knowledge transfer, temporary teams of students, interns and professionals build stories about projects that are in the process of being designed and/or built. The Building Stories methodology has been applied in two different flavors: the original, all-in version, which constitutes the focus of this paper, takes shape in an

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[2] Austin identifies certain statements in English that cannot be characterized as imperatives, because to utter them is "*not to describe the doing of what is to be said, but in so uttering to be doing …. The name performative is derived from 'perform,' the usual verb with the noun 'action': it indicates that the issuing of the utterance is the performing of an action*" (Austin 1975). Unlike ordinary practical knowledge, performative is an intellectual operation where (like knowledge-in-action) knowing is in the doing.

[3] At least two exceptions to this rule are worth mentioning here. One is the relatively recent attempt to capture the rationale behind decisions as they are taken during the design process (Cerulli et al. 2001). Another exception is the nationwide case study documentation program set up by the American Institute of Architects (AIA) to help improve American practice education (AIA 2004). The intent is to develop a new body of knowledge regarding architectural practice through rigorous preparation and publishing of case studies following a detailed Development Checklist.

experimental course spanning an entire semester; the light version consist of a one-week workshop, which squeezes the activities of the original version into five intensive days.

An experimental course

'Building Stories: A Case Study Analysis of Practice' crystallizes the Building Stories methodology by engaging teams of architecture students, architectural interns and seasoned professionals in exploring the knowledge capital embodied by the best practices of significant architectural firms in the San Francisco Bay area. Each team is composed of two students, plus one intern and one project advisor provided by the firm designing the project. The student faction contains at least one Master of Architecture student and two recent graduates serving as interns in an architectural practice. The project advisor acts as a conduit for access to the materials for the project under study. In addition, the firm, at its discretion, may introduce team members to consultants and other professionals involved in the design, management and construction of the project. Professional students are given formal IDP (Intern Development Program) credit toward their requirements for internship and licensure. The project advisor and other major participants of the firm receive AIA continuing education learning units for their involvement.

The course combines a guided set of activities in a case-based method of instruction. Students and interns enrolling in the course follow two parallel and complementary learning agendas. One provides a theoretical and methodological framework for undertaking a case study through storytelling. The second constitutes the active engagement into building one or more stories about a selected project, by analyzing primary source documents and interacting with practitioners responsible for it. Weekly lectures/discussions make students and interns familiar with the materials of the Building Stories approach, and with critical questions to explore the richness embedded in real-world projects, while opening up a dialogue on the rigorous study of broader aspects of the profession. In addition, students and interns team up with their project advisor on a regular basis, to discuss key issues of the project that address general aspects of the profession, and to evaluate progress of their investigation and stories.

During the first seven weeks, each team investigates the—up to then—entire history of their project, using six categories as a guideline to organize and direct their investigations: project definition, clients' aspirations; marketing process, project team organization & work plan; design process from schematic design to construction documents; project construction management & administration; commissioning, measuring of project success, post occupancy evaluation; and examples of practice innovations. This first half of the course concludes with an interim report and presentation covering the specific detail characteristics noted above. In addition, each team identifies a series of issues or threads that provide an opportunity to build stories during the second part of the course. These represent themes like unique clients' circumstances, special financial conditions, or particular organizational structures that give direction to unfolding a specific story. The second half of the course concentrates on "putting flesh on the skeleton", i.e. formally constructing the story details. The story is developed much in the same manner as one would write a novel. The plot or thread is positioned—a failed bond issue; the characters are illuminated—the introduction of a construction advisor as the client; and the settings of the actions established—a revised firm organization to value engineer the originally proposed scope, schedule, and budget. Over the next six weeks, new chapters are added, giving meaning and understanding to the story. The final report includes the stories produced by the team, along with the information collected during the investigation.

Outcome

At the end of the semester, the final reports are posted on a public website, making the experience and insights they capture worldwide accessible. So far the website features more than 22 stories about 12 different cases, ranging from the San Francisco Zoo (designed by Field Paoli

Architects for the City of San Francisco), over the Mount Zion Outpatient Cancer Center (by SmithGroup for UC San Francisco) to the new De Young Museum (by Herzog & de Meuron in collaboration with Fong & Chan Architects for the Corporation Of the Fine Arts Museums). It serves both as a repository of stories about design practice, and as a foundation for further research on the projects in future courses. As such, Building Stories could potentially serve as a means for sharing insights and experiences from practice with students, educators and researchers, but also with contemporary and future colleagues (Heylighen et al. 2004, Martin et al. 2005). The latter is more spectacular than first meets the eye given the notorious nature of the architectural profession sketched above.

However, the growing on-line story repository is but one mechanism of knowledge sharing in the Building Stories program. An additional mechanism derives from the fact that Building Stories teams are inherently heterogeneous in terms of the skills and experience team members bring to it (Heylighen et al. 2005). At the end of the program, the temporary network of students, interns and professionals dissolves. Yet what they have learned from each other creates a competence that becomes highly valued in their respective environments, be it practice or academia. The expertise and hands-on experience of the professionals in the team enable students and interns to develop a critical understanding of the issues and tasks of design practice. In return, the participation of students assures a continued supply of competencies trained in the latest research skills and techniques. Moreover, the (academic) knowledge networks they have access to, and the time and energy they can invest, make them highly attractive to design practice. Judging from our observations during the past five years, this newly acquired competence—the skills, attitudes and perspectives which follow team members to other projects and contexts—seems at least as important and valued a form of sharing as the on-line story repository.

PARTICIPANTS SPEAKING

In Fall 2004, we organized a seminar 'Building Stories Revisited' to create a platform for studying the process and outcome of Building Stories in previous years in relation to the more general discussion on knowledge in architecture. Through the seminar, we tried to substantiate our first observations and verify to what extent the program manages to unlock the knowledge capital of architectural practice. The seminar largely took shape in four roundtables: the first three with students, interns, and professionals who participated in Building Stories in previous years; the fourth with principals of major design firms in the San Francisco Bay Area. The aim was to get a more articulate understanding of what participants take home from Building Stories, and of its position in relation to the larger phenomena of knowledge production, management and exchange in architectural practice.

For the undergraduate students, some of which were part-time interns in the firm sponsoring their case, working on a Building Story gave them a better picture of what really goes on in an architecture firm. They gained insight in a lot of technical issues, but also in how different players work together to form a team, and how the nature of the team and the mode of communication within affect the resulting building. As one student put it,

> "*The case study touched on parts that I would have never experienced with internship alone. I was able to better understand the complicated process of getting a design built to finish, which I can apply to what I learn in classrooms and result in even a greater comprehension of the architecture world. I feel I have become less of an ignorant student, who has no idea or even cares about how work is done in real life, and have grown more consideration and admiration for the work architects as well as all different players within a project team do.*"

Another former undergrad/intern especially expressed admiration for the multitude of roles architects play beyond designing, roles he did not even think of when coming out of school.

In addition to this 'reality check'—and for some even 'shock'—one graduate student appreciated the opportunity to effectively conduct interviews before starting her master's thesis. In her view, Building Stories should be marketed as a flight simulator for practicing research methods to any student planning to conduct qualitative research on architectural practice. Moreover, since her participation in the class, she regularly draws on the story repository as a mine of information for various purposes.

The young professionals, for their part, turned out at least as enthusiastic about Building Stories as the students, yet had more difficulty explaining why: "*What you're getting out of it is ephemeral, it's not clear-cut knowledge*." One of them originally intended to present his experience to his colleagues in the firm, but never did so because "*they wouldn't understand it; they almost have to go through the process themselves*." When asked again what made this process so interesting, he mentioned the opportunity to trace as an outsider all the influences that shape a building. What happened to this project could happen again in his career later, whence his interest in how they solved it. Another young professional wanted to participate in Building Stories because he had always admired the architect designing the building under study. Unlike what he had hoped for, however, his participation did not provide the magical insight into how his idol creates good design. What it did provide was a bit of grounding, and a more realistic picture of what a successful architect does: "*it's not because he [his idol] is an excellent designer that he got to dictate the whole project.*" Moreover, he no longer felt it was so important to work for this specific architect, because he saw how his work translated to everybody's work.

Which brings us to the 'idols', the seasoned practitioners, themselves. Did participating in Building Stories have something to offer for them and their firms? One of them above all appreciated the opportunity to draw on "*that resource on campus*", and to get "*a peak through a younger lens*." His colleague also enjoyed the opportunity to provide young people a window on the collaborative effort of design practice, the part of the profession he loves most. An advisor from another firm especially valued the larger perspective provided by the case study, as opposed to the detailed, day-to-day view practitioners tend to have: "*It's beginning to start a process for myself to analyze what happened, how the project evolved, … I enjoyed going back through the documents and realize: 'Oh my god, we really did this. I have to remember this for the next project!'*" By way of summary, the principal of a firm who participated repeatedly in the past five years situated Building Stories' value on three different levels. First of all, it equips the firm as a whole to be self-critical in an entirely new and systematic way, and to reflect on and record its process of creation for further refinement. The Building Stories teams did not only bring up many issues that clarified how the firm works, it also came away with a good feeling that this way of working actually has some validity. Secondly, at the level of the individual employees, young professionals in the firm get a great opportunity to see what other firms are doing "*without having to put together their portfolio*." And finally—and perhaps most spectacularly—Building Stories makes collaboration and sharing a reality in a profession that is known to be highly secretive.

After the roundtables, the students enrolled in the seminar (all of which were Ph.D. researchers) were given several assignments to connect the topic of the seminar to their thesis subject. Throughout several papers they were asked to discuss the role of knowledge, as related to their thesis subject, in the projects reported on by the stories available on-line; in Building Stories, both as process (approach, methodology) and as product (the stories); and in architectural practice and education at large.

At first, the researchers were highly skeptical about the capacity of the stories as vehicles for knowledge transfer. Yet, eventually, the story collection turned out to be a surprisingly valuable resource for their Ph.D. research. For example, one of them found several stories mirroring his hypothesis that the notion of collaboration (the focus of his Ph.D.) is often used interchangeably with other terms (cooperation, coordination). Looking at the stories, at how students view real-world projects, what they are able to dissect, lead him towards a more articulate definition of collaboration (Doctors 2004). Another Ph.D. student had a mainly theoretical interest in the notion of ethics, but found looking at practice nevertheless fruitful. She realized that practitioners don't stop and think until there is a conflict disturbing the normal flow of progress. The stories contained multiple examples of such 'moments of resistance', mostly due to people having different roles or goals (Becker 2004). A third participant used the story collection to identify manifest instances of knowledge production (Hoque 2004). She found the collection very useful to her research in providing her with real-world examples to work with.

DISCUSSION

According to Habraken (2003:7), "*a profession's identity is defined in terms of knowledge and skills. It will be asked: What is it your profession knows that others do not? Do you have the skills and methods to apply that knowledge successfully?*" As pointed out above, the architectural profession seems to combine an alarmingly absent knowledge base with an exceptional cultivation of "knowing-in-practice", i.e. knowing how to integrate multiple elements from various sources and disciplines into one coherent whole. In view of this, Habraken (1997:284-285) argues for a revaluation of the shared knowledge of space and built form, to the extent that it reflects the agreements honored by those acting on it. He feels that the implicit way in which this knowledge used to present itself in systems, styles, patterns and types, no longer suffices and calls for deliberate study on how its application (or lack thereof) impacts the health and quality of the environment. In essence, Habraken's proposal comes down to (re)establishing architecture's knowledge base by studying the *outcome* of architects' knowing-in-practice.

Building Stories adopts a similar, yet significantly different approach, in that it proposes to (re)establish the former by exploiting the *process* of the latter. Through storytelling, it tries to capture and share architects' knowing-in-practice as it presents itself in designing and building projects and, as such, to do justice to the performative nature of architectural knowledge. As far as the capturing part of Building Stories is considered, further work is needed in order to improve and guard the quality of the resulting stories. Interestingly enough, however, this does not seem to hamper the sharing part. The outcome of the seminar reported on above strongly suggests that Building Stories is particularly successful in creating entirely new opportunities and interfaces for exchange. Judging from the roundtables and the Ph.D. students' research papers, the initiative seems to provide an inventive methodology for catalyzing knowledge sharing between projects ("*I have to remember this for the next project!*"); between individual architects and architecture firms (through the on-line story collection, but also through the participation of young professionals); and between practice and academia (equipping design firms to draw on "*that resource on campus*" and vice versa). As such, Building Stories offers architectural education a tremendous pedagogical device, provides architectural practice with an effective vehicle for self-critique, and even may serve as a valuable resource for architectural research.

Obviously, however, it is far too early to draw general conclusions based only on three roundtables and just as many research papers. The question remains whether Building Stories has a role to play in the larger context of knowledge production, management and sharing in contemporary architectural practice. Despite repeated attempts to schedule the fourth, more general roundtable, we did not manage to bring a number of principals around the table to testify about knowledge production, management and exchange in their firm. Should this be taken to suggest that architects' notorious secrecy stubbornly persists? Or is it a matter of patience until the next generation has arrived? Meanwhile, however, other design firms and architecture schools have expressed their interest in Building Stories, which provides us every reason to continue our attempt at unlocking the knowledge capital of architectural practice.

Acknowledgements
Ann Heylighen is Postdoctoral Fellow of Research Foundation, Flanders (F.W.O., Vlaanderen). The William Wurster Society sponsors have provided support in the form of access to active projects in their firms and base funding for the development of the Building Stories course at UC-Berkeley. We would like to thank all who participated in Building Stories and/or the seminar "Building Stories Revisited" and Sam Michiels for his invaluable comments on earlier versions of this text.

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VISUAL LANGUAGE IN ARCHITECTURAL DESIGN

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Abstract
The globalization of economics, technology and culture become the main trends of the modern economy. The emergence of new forms of local and global cultures characterizes the media landscape of the early twenty first century. Sturken & Cartwright (2001) maintain that visual culture, which generally does not observe difference in language and levels of literacy, is key in this climate of globalization. According to Walker & Chaplin (1997) the field of visual culture has four domains (Fine Arts, Crafts/Design, Mass & Electronic Media and Performing Arts) and architecture belongs to the Fine Arts domain. This paper examines firstly whether all domains within the field of visual culture can be sources of ideas and inspiration in architectural design and secondly the visualization tools that can be employed to express and communicate these ideas. McKim's (1980) graphic abstraction ladder (with two levels of the concrete and abstract graphic languages) has been analyzed and used as a base to add the new level of the hybrid graphic languages that are about storytelling based on all domains of visual culture. The extent to which the industry is aware and exploits the opportunities offered by the suggested theoretical model is also explored. The research results helped in forming an aggregate view describing the main drivers and idea generators in the modern commercially driven architectural market.

Keywords: Architectural Design, Creativity, Visual Culture, Visual Language.

INTRODUCTION

Modern life is mediated through the visual screen. Film, television, and the Internet are not just the norm, they are life itself erasing national boundaries and creating cross-cultural exchange. The new emerging globally shared visual culture becomes the underlying construct that explains and substantiates visual experience in everyday life. Mirzoeff (1999) summarizes briefly some Western cultural practices that favour the verbal format of communication over the visual representation of ideas. The emergence of visual culture creates the premise for adopting a pictorial, rather than textual view of the world and even literature studies have been forced to conclude that the “world-as-a-text” has been replaced by the “world-as-a-picture”.

Walker & Chaplin (1997) in *Visual Culture: an Introduction* give a detailed definition of visual culture as being the “material artifacts, buildings and images, plus time-based media and performances” and identify its four domains – Fine Arts (painting, sculpture, drawing, avant-garde films and videos, architecture), Crafts/Design (urban design, industrial design, illustration, graphics, product design, CAD, landscape design), Performing Arts/Arts of Spectacle (theatre, ballet, dance, theme parks, planetariums) and Mass/Electronic Media (photography, cinema/film, television, Internet, virtual reality, computer imagery, illustrated books).

This study examines the richness of visual language in architectural design as an expression of the relationships between the domains of visual culture. It explores the extent to which the industry is aware and exploits the opportunities offered. This study also investigates standard practices analyzing the predominant array of visual tools used by the architectural profession.

Architecture belongs to one of the four domains of visual culture. What about the other three?

According to Walker & Chaplin (1997) architecture is a component of the Fine Arts domain of visual culture alongside paintings and sculpture. The other three domains – Crafts/Design, Mass and Electronic Media and Performing Arts do not seem to be considered in any kind of relationship with architecture. Hence the impact of visual culture as a whole on architectural design has been neglected and undervalued by the profession. A more flexible approach to visual culture will allow exploring the overlaps between architecture and the other constituent components of the same "Fine Arts" domain and also establish unexpected relationships between architecture and the other three domains of visual culture. These new emerging connections and combinations can be sources of inspiration and ideas that can influence significantly architectural design. At present the architectural profession seems to be reluctant to explore the other three domains of visual culture restricting itself to the domain of the "Fine Arts" only. Even the relationships between architecture and the other constituent parts of the same sub-field as art and sculpture have not been sufficiently analyzed and capitalized upon.

Limited use of graphic languages by the architectural profession

Applying the model of the "graphic abstraction ladder" as introduced by McKim (1980) reveals that there are two main groups: abstract and concrete graphic languages. The group of the concrete graphic languages, or the first step of the ladder, comprises orthographic, isometric, oblique, and perspective projection. Three-dimensional modelling is considered to be at the end of the abstract-to-concrete ladder of graphic languages. The group of the abstract languages, or the second step of the ladder, comprises charts, graphs, diagrams and schematics. The architectural profession as a whole seems to limit itself mainly to the first step of the ladder – the concrete graphic languages. There is a well-manifested unawareness among design professionals that the group of the concrete graphic languages can be just one answer to a design problem. It can be argued that this fact is a result of the combination of two reasons – the commercially driven nature of the architectural design process and the lack of adequate exposure to such concepts in an educational setting. In comparison the great masters of architecture use the whole range of concrete and abstract visual languages and explore unusual sources of inspiration to create memorable and unique designs – traditional huts with thatched roofs, seaweeds, paintings, sculptures and the beauty of the human body. In contrast everyday commercially driven architecture remains surprisingly remote from such poetic notions.

THEORETICAL ASPECTS OF VISUAL CULTURE AND VISUAL COMMUNICATION

The building blocks of the proposed theoretical model.

Visual Culture

The advantage of such a large and diverse visual culture field as defined by Walker & Chaplin (1997) is that the application of different approaches and points of view can lead to different interpretations. Using architectural design within the field of visual culture (and more concretely in the Fine Arts domain) as a starting point and exploring the overlaps with the other constituent components of the same sub-field on one hand and with the other three domains of the visual culture field on the other hand, is one approach that gives interesting and unexpected results. In this respect the use of references relevant to a specific theme can be of diverse nature – ranging from paintings, sculpture, and landscape design to photography, film and television. According to the author's own opinion, it can be argued that architecture in fact belongs to the Crafts/Design domain sharing common concepts and principles with urban design, landscape design, engineering design, CAD and so forth. Positioning architecture in the Fine Arts domain together with paintings, sculpture, print-making, mixed media forms and so forth requires a more abstract level of thinking as the relationships are not that obvious. The discussion that develops further is based on the premise that whether architecture is positioned in the Fine Arts domain (Walker & Chaplin, 1997) or in the Crafts/Design domain according to the author, this would not change the essence and the course of the argument as the primary purpose is establishing relationships on a local domain and on an interdomain level.

Exploring a relationship on a local domain level can be exemplified with art and architecture, which belong to the same domain of the Fine Arts. How art relates to architecture can be examined from different angles: the simplistic approach would be referring to art on a literal level – for example, the display of cultural artefacts in buildings (Maori carvings in New Zealand architecture, Aboriginal paintings in Australian architecture, Shona sculptures in Southern African architecture). Another more complex and comprehensive approach would be analysing art on a symbolic level and using art references in relation to a particular architectural project. Frank Gehry's Guggenheim Museum in Bilbao, Spain exemplifies this approach. Vanessa Castellano (1998) perceives the building as "a huge futurist sculpture". She maintains that Gehry's fascination with art has found true expression in Guggenheim. The architect himself believes that ideas in architecture actually come from art. "The building was inspired by Pablo Picasso's famous cubist work 'The Accordionist', and the successful architectural interpretation of that painting is what makes Gehry's achievement unprecedented" (Castellano, 1998).

Using the Visual Culture concept as introduced by Walker & Chaplin (1997), the connection between architecture and the other constituent parts belonging to the same group of the Fine Arts can be established more easily while the relationship between architecture and performing arts, for example, is of a more obscure nature. Using Toyo Ito's Sendai Mediatheque in Japan as an example it can be argued that the artistic elegance of the mesh columns of the building emulates the grace of ballet movements, a comparison made by Toyo Ito (2001). Similar examples can be used to illustrate the relationships between architecture and the other domains of the Visual Culture field. These relationships in some instances are quite obvious especially when linking architecture to CAD, graphics, urban design and landscape design belonging to the Crafts/Design domain or when establishing connections between architecture and the Internet, virtual reality and computer imagery, all part of the Mass and Electronic Media domain.

Visual Communication

If we continue the argument that all domains of visual culture can be sources of ideas in architectural design then what visual tools can be employed to represent them? This suggested theoretical model contains two interrelated research questions.

McKim (1980) in *Thinking Visually* argues that all graphic languages fall into two main groups: abstract and concrete. The abstract ones embody abstract ideas and convey messages on a different level unlike the concrete ones that aim at more accurate graphic representation of an idea. The "graphic abstraction ladder" presented by McKim shows the two main categories of visual languages along the dimension of abstract-to-concrete. "By distinguishing abstract from concrete graphic languages, I hope particularly to dramatize the abstract dimension of graphic-language thinking" (McKim, 1980).

The group of the abstract languages comprises charts, graphs, diagrams and schematics. The group of the concrete graphic languages comprises orthographic, isometric, oblique, and perspective projection. Three-dimensional modelling is considered to be at the end of the abstract-to-concrete "ladder" of graphic languages. McKim argues that the variety of graphic languages (from ancient to modern and from abstract to concrete) creates a premise for recentering a person's thinking by moving from one graphic language to another. In architectural context an idea can be generated starting with an unusual perception, notion, or vision and turning it into architectural design. This can involve using references from the other domains of visual culture like Crafts/Design, Mass and Electronic Media and Performing Arts. The great minds in architecture have proved that nature (Toyo Ito), the human body (Santiago Calatrava), paintings (Frank Gehry) and indigenous architectural structures (Renzo Piano) can inspire the creation of iconic, original and fascinating architecture. Their approach to design is not about obsession with a design brief; it is about inspiration, gestalt (seeing the whole rather then just the parts), graphic ideation and externalized thinking. The result is architecture that tells a story in a poetic way. This line of thinking suggests an expansion of McKim's graphic abstraction ladder by adding a new level – the hybrid graphic languages, the essence of which is storytelling based on references from all domains of visual culture. In other words storytelling based on references from all domains of visual culture can be considered as the "content" and the new proposed category of the hybrid graphic languages – the "visual tools" representing that content.

ANALYSIS OF THE INDUSTRY RESEARCH IN AUCKLAND, NZ

The logical question is: How does the reality match this theoretical and abstract model? The purpose of the industry research carried out by the author of this paper in Auckland, New Zealand was to establish everyday practices and analyze guiding notions, idea generators and metaphorical thinking in design and then compare it with the suggested theoretical model.

Ten architectural companies – five large (from 30 people upwards), three medium (10-15 people) and two small (3-5 people) were interviewed for the purposes of this research. The size of the practices was just one criterion for selection with the other one being the portfolio of the firm. The author's preference was to interview companies involved in commercial type of projects. A good cross-section of people has been included - interviewees were Project Directors, Design Architects and Assistant Architects. The selected range of people was determined by the type of work they were involved in and namely the design phase of a project. Extensive organisational background research preceded the actual interviews. The semi-structured interviews aided by a specifically designed questionnaire were complemented by observation and document analysis of projects presented at the interviews for discussion. The main purpose was to explore only certain aspects of the design process or the phase when sources of inspiration are explored and ideas generated. The research results have been analyzed by the author in that respect forming a representative study of a small segment of the market in New Zealand at a specific time. Visions, approaches to design, importance of creativity and innovation to the quality of design vary significantly from one firm to another reflecting a diverse range of values, interests and preferences. The research results helped in forming an aggregate view. The original quotes by the interviewees have also been included throughout the narrative.

The Vision

There are three scenarios for developing the vision when working on a project – it can be either a team effort (usually in larger offices), a result of collaborative work involving the Director and the Project Architect, or a combination between any of the above two and a Client's input, which in some cases can be very significant ("around 60%"). One implication then is that the vision often departs from the poetic realm and turns into a pragmatic brief with items to be covered. Architects defined several sources of inspiration. For some the actual site with its idiosyncrasies is seen as a major source of inspiration while for others it is not "the physical site only" that they are interested in, the site is regarded as "a threshold", a reason to start looking at the "fabric around it" and explore "connections beyond the site boundaries". For most architects looking at magazines with similar buildings or the work of others is a common practice, the reason for this being forming an aggregate view that will later inform the concrete design through the "crystallization of the idea on a subconscious level". Interestingly enough nobody from the interviewees made any reference to the other domains of visual culture. In contrast architecture inspired by nature, tradition and the beauty of the human body that searches for poetry and lyricism in buildings is what unites the work of some of the great masters in architecture – Renzo Piano, Frank Gehry, Toyo Ito and Santiago Calatrava. Seeing "seaweeds" and "ballet" (Sendai Mediatheque in Japan, Toyo Ito), "the human body" (Lyon Airport Railway Station, Liege Railway Station, Montjuic Communications Tower in Barcelona, Santiago Calatrava), "paintings" (Guggenheim Museum in Bilbao, Frank Gehry) or "traditional huts" (Tjibaou Cultural Centre in New Caledonia, Renzo Piano) as diverse sources of inspiration was perceived as a "risky field", which was explained with the need of "aligning our desires with the client's expectations". In other words, some clients prefer simple buildings, are interested in the quality of execution and see ideas exploration as a challenge with undesirable time and budget implications. In other projects the general approach to design is much more sophisticated as it is not concerned only with site context (north orientation, prevailing winds, noise control, access to the site) but also with "the social aspects of the job." Only in one of the large offices there was a practice of including imagery in the design concept. Various images in the range of a hundred with references pertinent to the project were explored as sources of inspiration as the director explained. Later they were narrowed down to about ten really meaningful ones, which helped to explain the whole concept.

Preliminary Design

All interviewed architects communicate their ideas to the client by using orthographic (manual or CAD) drawings, sketches and only in a few firms "some diagrams". Appropriate body language and a persuasive style of presentation are also considered as part of the whole package. The clients being property developers and managers functioning in a highly "commercialized environment" were predominantly described as "money and profit oriented". In such a "cruel reality" bringing imagery, which is not about concrete buildings that can potentially be liked by the client and copied, and making abstract associations was not seen as a viable option. It is interesting to be noted that at the same time overseas such ideas obviously get their proponents and end up becoming masterpieces - a landmark of a city. In that respect one of the interviewed architects made the statement that "New Zealand produces a very good domestic architecture but unfortunately does not go beyond that".

Presentation Drawings

Apart from manual sketches that are discussed with the client, in all firms the most popular way to produce presentation drawings is through the use of CAD drafting packages (AutoCAD, ArchiCAD, Vector Works), as well as Photoshop and Power Point and only in one large office, Page Maker. All interviewees unanimously stated that clients prefer hard copies and only in certain cases they are accompanied by a Power Point file on a CD-ROM. Some offices, especially the smaller ones, sub contract out some of the perspectives (CAD and manual), as they do not have the expertise in house. The larger firms produce everything internally. Regardless of the computer software with all the sophistication that it entails on a technological level, all interviewed firms seem to operate in the realm of the "concrete graphic languages" (McKim, 1980) that is producing drawings, orthographic ones and perspectives.

Only in one large company the level of the "abstract graphic languages" (McKim, 1980) was also represented alongside the concrete one through communication diagrams, environmental studies and bubble diagrams. This approach was not perceived as necessary in the other firms as the level of the "concrete graphic languages" seemed to serve the purpose without excessive extravagance.

In conclusion visual language in architectural design was described by all interviewed architects as "presentation drawings - orthographic or perspectives". Pertinent images evoking feelings, emotions and associations and using references from the other domains of visual culture with connotations of remoteness rather than immediacy were not something experienced and experimented. In other words, looking at similar buildings, when working on a specific project, would be the preferred approach rather than searching for abstract images to convey meanings and emotions thus shaping the design philosophy. Seeing "seaweeds", "ballet", "the human body", "paintings" or "traditional huts" as diverse sources of inspiration should not be perceived as a "risky field" as one of the interviewees put it. If we continue to strive to "align our desires with the client's expectations" we put ourselves at risk to simply add another conventional and uninspiring building to the heritage that already exists.

Summarizing the research outcomes of the industry research it can be concluded, with the reservation that this study is a snapshot of a relatively small sample, that there is definitely a discrepancy between espoused values and reality on a local industry level caused mainly by the commercially driven market and on a more global level a profound difference between approaches to design, that ones of the great masters in architecture and the everyday routine practices of the other architectural professionals. The main reason that can be identified is the commercially driven architectural market imposing constraints in terms of time and budget as well as the strongly dominating figure of the client.

CONCLUSION

The broad realms of visual culture and visual communication were examined in this study in order to provide the theoretical framework within which the discussion would evolve. It was further contextualised through Walker & Chaplin's (1997) diagram of the field of visual culture with its four domains (the diverse sources of ideas) and McKim's (1980) graphic abstraction ladder (the design tools). The two research questions posed in this study and derived from the suggested theoretical model were: 1. Can all domains of visual culture be sources of ideas in architectural design? 2. If so, what visual tools can be employed to represent them? Two research methods – an ethnographic one (literature review) and semi-structured interviewing have been employed to answer these questions.

The primary research conducted with ten architectural firms of different sizes (large, medium and small) showed general unawareness in the architecture profession of the field of visual culture in the broad sense of the word and limited use of graphic languages. Standard practices and conventional methods are widely spread and still the norm in a commercially driven architectural market. A comparison between these research results and the way the great masters in architecture approach design shows that metaphorical thinking and the use of references from all domains of visual culture are still for exclusive rather than ubiquitous use. Benedikt (1999) argues: "architecture, as an industry, broadly conceived, has become less and less able to deliver a superior, evolving, and popularly engaging product that can compete with other, more successful products – with cars, music, movies, sports, and travel". Similarly, Schwarzer (2000) contends: "our eyes are conditioned by film, video, and computers to see objects in states of representation, dramatization, animation, and of course, commodification. By comparison, most buildings appear lethargic, devoid of life".

In conclusion, the answer to the first research question is that all domains of visual culture can be regarded as sources of ideas supported by the inspiring designs of the great masters in architecture. The field of visual culture as defined by Walker & Chaplin (1997) is huge and can be approached from a different viewpoint. The focus of this paper is on the design process in architectural context and particularly on the development of a visual language for richer outcomes. McKim's (1980) graphic abstraction ladder (with the two levels of the concrete and abstract graphic languages) has been used as a base to add the new level of the hybrid graphic languages, which is about storytelling based on all domains of visual culture. Schwarzer (2000) poses the question about future architectural creativity, apart from matters of efficiency and comfort, suggesting that architects should rethink their identities and action within the commodified built landscape. In this view architectural sensibility and creativity emerge as the driving forces in the art of creating buildings.

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JOB-RELATED WELL-BEING IN THE ARCHITECTURAL PROFESSION: AN EXPLORATORY STUDY

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Abstract
Research investigating psychological well-being amongst the construction industry professions indicates that the sector places stress on its employees, particularly in terms of time pressures, long working hours and high workload, which negatively affect employee well-being. This can manifest itself as sickness absence, turnover intentions, burnout and relationship conflict. Research with female architects suggests that they are vulnerable to similar stressors as other construction professionals. This paper presents the findings from the first phase of research examining the psychological well-being of male and female architects. A questionnaire was emailed to architects working in many areas of the UK, collecting data about, job satisfaction, physical symptoms of stress, work-life conflict, job demands and turnover intentions. Initial analysis suggests that a significant proportion of respondents work long hours, are dissatisfied with pay, working hours, practice management and recognition of their work. Most respondents showed evidence of job-related stress and work / life conflict and around a third of respondents were actively seeking to leave both their current job and the profession. It is argued that the findings have serious implications for the future growth and development of the profession.

Keywords: Architects, job satisfaction, turnover, wellbeing, work-life balance

INTRODUCTION

Psychological well-being in the workplace is an area of increasing interest in the construction management literature. There still remains however considerable scope for further work which can determine how working in the construction industry affects those working within it. This paper presents the findings of research which has explored the levels of well-being experienced by those working in the UK architectural profession.

Psychological well-being in the construction industry

Well-being is an emerging topic within construction management literature with work to date has suggested that working in the construction industry exposes employees to a number of potentially harmful stressors. For example, research undertaken with civil engineers suggested that working in the construction industry can lead to poor experience of marital type relationships (Lingard and Sublet, 2002). In particular, high levels of responsibility, work overload, role conflict, and long working hours were associated with relationship conflict (ibid). Further work with civil engineers found a significant relationship between role conflict, responsibility, satisfaction with pay, feelings of professional worth and burnout (Lingard, 2003). Further more Lingard (2003) identified a link between symptoms of burnout and a intentions to look for a new job. In light of the skills shortages currently facing the construction industry (Dainty et al 2004) this is an important finding. Haynes and Love (2004), examined well-being amongst construction site managers. A number of important stressors were identified in this research, in particular, high workload, long working hours, insufficient time spent with family and small project size (Haynes and Love, 2004). Haynes and Love (2004) argue that this may lead to projects not running to time or budget, and therefore not meeting the increasing needs of clients.

All the studies discussed above were conducted in Australia. Although work undertaken within the UK construction industry is sparse, two important studies have explored well-being amongst

UK site managers (Sutherland and Davidson, 1993) and project managers (Sommerville and Langford, 1994 and Love and Edwards, 2005).

Sutherland and Davidson (1993) explored stress amongst site managers, identifying poor job satisfaction, time pressures, long working hours, work overload, role insecurity as stressors and predictors of poor mental health. Sommerville and Langford (1994) identified time and cost pressures in addition to relationships within the project team as stressors for construction project managers. The use of 'unhealthy' coping strategies such as alcohol and cigarettes suggests that exposure to stressors can have a negative impact on physical health. Interestingly Sommerville and Langford (1994) indicate that a significant proportion of their sample had family members employed within construction. These respondents reported less difficulty adapting to working life within the sector, than those who were entirely new to construction. This suggests that realistic expectations of working in the sector may mediate the effects of stressors.

Over a decade later Love and Edwards (2005) identified similar stressors, in particular long working hours and a lack of social support. This suggests that despite the introduction of initiatives such as *Respect for People* (2000), the experiences of those working in the sector have shown little improvement. These findings echo those of the Australian studies discussed above, suggesting that workers in the UK construction industry are vulnerable to similar stressors.

This paper presents the preliminary findings from a PhD investigating psychological well-being amongst those working in the architectural profession. Architects occupy a vulnerable position within the construction industry, as they are particularly susceptible to fluctuations in the demand for construction. In addition architects are finding their traditional project management role eroded by the introduction of new professions which are able to undertake these duties (Emmitt, 1999). This may damage feelings of professional worth which are associated with burnout (Lingard, 2003). These factors may mean that in addition to the stressors experienced by other construction professionals, architects may experience additional stressors. To date, no work has been carried out examining psychological well-being amongst architects working in the UK. However, work undertaken by the Royal Institute of British Architects (RIBA), suggests that aspects of the architectural profession lead women to seek alternative employment, including, dissatisfaction with pay, long and inflexible hours, stressful working conditions and poor job satisfaction (RIBA, 2003). Further work by Caven (2004), identified sources of dissatisfaction amongst female architects as; long working hours, little time off and lack of job autonomy. Although this research did not explicitly investigate well-being, they suggest that female architects may experience similar problems as male site managers, civil engineers and project managers, and as such are at risk of poor well-being.

In summary, significant steps have been taken to investigate the psychological well-being of those employed within construction industry professions. Existing work has demonstrated that a number of stressors are experienced by those working in construction, for example, long working hours, high work load, role conflict, professional worth, poor work life balance and relationships with team members. Initial work with architects suggests that they may also be subject similar stressors.

METHODOLOGY

In order to determine levels of well-being experienced by architects a self-completion email questionnaire was used. The questionnaire was structured using items used in previous research, helping to ensure reliability and validity. In addition, given the potentially sensitive nature of the research, the questionnaire allowed respondents to answer questions at their own speed and provided anonymity. These are both advantages to the use of self-completion questionnaires (Fink and Kosecoff, 1985). The questionnaire identified levels of well-being through an assessment of job satisfaction, physical symptoms of stress, work-life balance, job demands and turnover intentions.

Job satisfaction

Job satisfaction was assessed by using an amended version of Warr, Cook and Wall's (1981) scale of Global Job Satisfaction. Amendments ensured that the scale was directly applicable to architects. The coefficient alpha for this scale was $\alpha = .9104$

Physical symptoms of stress

The Physical Symptoms Inventory (PSI) was used to assess the physical symptoms of psychological distress amongst architects. This scale was developed by Spector, et al (1988) and has been shown to have a strong relationship with job satisfaction and job characteristics (Spector et al, 1999).

Work-life conflict

A seven item scale was developed, using existing tools as a template (Small and Riley; 1990 and Bacharach, Bamberger and Conley; 1991 c.f. Fields, 2002). Respondents were asked to rate the extent to which they agreed with a number of statements regarding work life balance. The coefficient alpha for this scale was
$\alpha = .8967$

Job demands

In order to investigate this phenomenon amongst architects, Karasek's Job Demands and Decision Latitude scale was used (Fields, 2002). This scale demonstrates high validity and reliability (Fields, 2002). The coefficient alpha for this scale was
$\alpha = .7684$

Turnover intention

A four-item scale was developed which asked respondents to state the extent to which they agreed with statements about turnover desires and active turnover intentions. The coefficient alpha for this scale was $\alpha = .8349$

Distribution of the questionnaire

The questionnaire was distributed to 1200 architects working in different areas around the UK. After follow-up requests were made, a total of 110 fully completed questionnaires were received, a response rate of around 9%. Contact details of architects were found using the websites of the Royal Institute of British Architects (RIBA) and the Architects Registration Board (ARB). In order to contact those working at part III or lower a short article was published in Building Design magazine, which summarised the aims of the research and provided contact details for the research project. This publication is a professional journal that is distributed to all people working within the architectural profession. The student body of RIBA, ARCHAOS was also contacted, and a copy of the questionnaire was placed on their website. In this manner it was possible to gather data from people working in all levels of the architectural profession.

RESULTS

Sample characteristics

The sample consisted of 75 males and 35 females. The age of respondents ranged from under 25 to over 60 with a mean age of 35 to 40 years (SD = 2.234). The majority of respondents identified themselves as White British or Caucasian (78%). 61% of respondents were either married or living with a partner, 36% were single and the remaining 3% had a partner that they did not live with. The majority of the sample had no dependents (57%), 41 % had three or fewer dependents and the remaining 2% had 4 or more dependents. The majority of respondents had achieved chartered architect status (65%), with a further 26% were registered with the ARB. The remainder of the sample (9%) were qualified at Part III level or lower. The number of years at highest level of qualification ranged from 2 months to 45 years, with a mean of 8.6 years (SD = 10.06). 81% of respondents were not self-employed and 96 % worked full time. Organisational size ranged from one employee (the self-employed respondents) to 900 employees. 71% of respondents had managerial responsibilities, supervising between 1 and 56 employees. Respondents were employed in a wide range of occupations. Table 1 shows the working hours of all participants.

	Mean	SD	Range
Hours worked on site	5.03	8.76	0-50
Hours worked in the studio / office	35.5	12.38	0-80
Hours worked at home	3.75	7.89	0-45
Total number of hours worked	43.23	12.27	0-80

Table 1. Showing statistics of working hours.

In addition 27.3 % of the sample worked in excess of 48 hours a week, indicating that nearly a third of the sample were contravening European guidelines regarding working hours (DTI, 2005). 64% of respondents had taken sick leave in the 12 months prior to completing the questionnaire, with a mean number of days of 3.27 (SD = 10.34).

QUESTIONNAIRE FINDINGS

The following section of the paper reports the descriptive statistics derived from the analysis.

Job satisfaction

No item on the scale had a mean score which indicated dissatisfaction. However, 3 items (rate of pay, opportunity of promotion and the way the practice is managed) had a mean rating of 'not sure' which may indicate some level of dissatisfaction. The frequencies of scores on each item was examined and the findings are displayed in Table 2. This shows that, while the mean satisfaction scores did not indicate dissatisfaction with any items, particular aspects of working as an architect were considered a source of dissatisfaction including, pay, opportunity for promotion, the way the practice is managed, hours of work, recognition for work, attention paid to suggestions, opportunity to use abilities, variety, job security and opportunity to use abilities. These accord with the sources of dissatisfaction identified by RIBA (2003) and Caven (2004).

Item	Percentage indicating dissatisfaction
Rate of pay	41.8
The way your practice is managed	34.9
Opportunity for promotion	33.3
Your hours of work	30.9
Attention paid to the suggestions you make	28.7
Recognition for your work	25.5
Opportunity to use your abilities	23.6
Your job security	22.7

Table 2. Showing the percentage of all respondents who indicated dissatisfaction with items on the job satisfaction scales.

Physical symptoms

Physical symptoms of stress experienced by the majority of the sample included fatigue (82.7%), headache (60.5%), trouble sleeping (58.7%) and eye strain (52.7%). Other commonly experienced symptoms were backache, diarrhoea, acid indigestion and restless legs, suggesting that architects are likely to experience the physical symptoms of stress. The majority of respondents did not discuss their symptoms with either colleagues or their line managers. This may imply that respondents did not view their colleagues or line managers a source of support.

Work-Life Balance

Examining the mean responses on each item revealed that for all items with the exception of 'I often arrive at work too tired to function because of household work I have done', the mean response was 3 indicating 'Neither agree or disagree'. Frequency analysis revealed that the majority of respondents reported that they found it difficult to switch off when they finish work (54.5%), and that they had come home from work too tired to carry out domestic tasks (61.5%). Approximately one third of respondents indicated that they agreed that their work negatively affected their family life, relationship, parenting and their social life. This suggests that work to life conflict is an area of concern to respondents.

Job demands

The job demands and decision latitude scale is divided into three subscales; job demand items, skill discretion and decision authority.

Job demand items: For all items with the exception of conflicting demands and insufficient time to complete work, which had mean ratings of 3.19 (SD = 1.01) and 3.05 (SD = .99) respectively (indicating they were experienced frequently), respondents had a mean rating which indicated they frequently faced job demands. This suggests that respondents often felt that their job had excessive work, there was too little time for them to carry out their work and that their jobs had a high workload.

Skill discretion: The mean score on each item indicated that respondents often felt that their jobs frequently required a high skill level (mean = 3.83, SD = .833). In addition respondents indicated their jobs frequently required them to learn new things (mean = 3.49, SD = .798), work in a non-repetitious way (mean = 3.38, SD = .846) and required creativity (mean = 3.22, SD = .999).

Decision authority: Mean scores indicated that respondents frequently felt assisted in making decisions (mean = 2.98, SD = .911), they frequently had control over their job (mean = 3.26, SD = 1.05), they often had the freedom to organise their own work (mean = 3.52, SD = 1.056) and they were often allowed to make their own decisions (mean =3.50, SD = 1.006).

Examining the mean scores for each item on the Job Demands and Decision Latitude scale suggests that conflicting demands, excessive work loads and time pressures place significant demands on the respondents. Karasek (1979) identified these items as psychological stressors, indicating that experience of them is an indicator of poor job related well-being. However respondents appear to have a high degree of decision latitude which can act as a mediator to well-being (Karasek, 1979).

Turnover intentions

The mean responses for each item on the turnover intention scales indicated that for all items respondents neither agreed with the statements, with the exception of 'I will be actively searching for a job outside of the Architectural Profession over the next 12 months' where the mean response indicated that respondents disagreed (3.97). However, an analysis of the frequency that each rating was reported reveal that 36.4% of respondents often think about leaving their job, 37.3% often think about leaving the architectural profession and 30% will be seeking a new job over the next 12 months. This suggests that for approximately a third of respondents their experiences as practicing architects impact their turnover intentions.

DISCUSSION AND CONCLUSIONS

The preliminary data analysis presented in this paper suggests that those working in the architectural profession experience a number of stressors similar to those reported in previous work with site manager, civil engineers and project managers (Love and Edwards, 2005; Haynes and Love 2004; Lingard, 2003; Lingard and Sublet, 2002 and Sutherland and Davidson, 1993). In addition, career and pay dissatisfaction have been identified as sources of concern to female architects (Caven, 2004 and RIBA, 2003). The data presented supports the findings of these earlier studies, suggesting that a large proportion of respondents are dissatisfied with pay, opportunity for promotion and use of skills, hours of work, practice management and the attention paid to their suggestions.

The high incidence of physical symptoms of stress amongst respondents suggests that architects may be vulnerable to poor job related well-being. The most commonly reported symptoms were fatigue, headache, trouble sleeping and eye strain, all of which were reported by over half of the sample. This data is worrying as it suggests that working within the architectural profession may have a direct impact on a person's physical and mental well-being.

Conflict between working and personal lives appears to be of concern to respondents, with significant numbers reporting that they found it difficult to 'switch' off after work and that they were unable to carry out domestic chores because of work. In addition to this, over a third of the sample reported concern over the effect that their work was having on their relationship and their social life. This supports the findings of Lingard and Sublet (2002) who argued that working in the construction industry exposes a person to long working hours and high workloads, which can damage relationship quality. Non work related social support is an important mediator of job related well-being (Geurts and Demerouti, 2003). If working as an architect affects relationship quality and enjoyment of social activities, then this could lead to poor job related well-being.

For the respondents of this study, there were significant job demands associated with working as an architect, especially, time pressures, work load and conflicting demands. This is potentially an important finding when placed in the context of existing construction management research, which highlight the relationship between these demands and poor well-being (see Love and Edwards, 2005; Haynes and Love 2004; Lingard, 2003; Lingard and Sublet, 2002 and Sutherland and Davidson, 1993).

The findings presented here have a number of implications for the architectural profession. Haynes and Love (2004) suggested poor well-being amongst project managers may lead to problems meeting the needs of clients and the over run of projects. Considering the important role of architects in the commission, planning, designing and management of the project (RIBA, 2005) there are significant implications for the construction process. If, as suggested here, working an architect exposes individuals to high levels of stress there are potential consequences for performance. Stress has been associated with reduced performance (Djebarni, 1996), harmful coping mechanisms (Haynes and Love, 2004), lower productivity (Arnold et al., 1991) and sickness (Comer, 2001). In addition there is concern over the impact working in the profession will have on retention (RIBA, 2003). Such factors may affect the image of the profession leading to problems with recruitment. In order to continue to attract and retain high calibre workers, the architectural profession must examine how it treats its employees and determine the impact of this treatment. This can then lead to steps to improve the well-being of architects.

Further analysis of the questionnaire will examine the relationship between gender and well-being, by comparing scores of male and female participants. There is a significant body of work which investigates the experiences of women working in the construction industry professions (see for example, Dainty et al., 2000). More recently RIBA (2003) and Caven (2004) have highlighted the difficulties experienced by female architects.

In order to identify relationships between variables, for example, work-life balance and job satisfaction, it will be necessary to perform non parametric correlational analysis. In addition factor analysis will enable themes within the data to be identified. The findings derived from such an analysis will inform in depth interviews with men and women working in the architectural profession. Undertaking qualitative data collection will enable for an in depth analysis of the relationship between working as an architect and their psychological well-being.

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EVALUATING THE INDUSTRIAL POTENTIAL OF DIGITAL OUTSOURCING IN ARCHITECTURE: METHODOLOGICAL CHALLENGES AND CHOICES

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Abstract
This paper is the first product of a two-year research program sponsored by the Australian Research Council in 2005. The project seeks to evaluate the industrial potential of distant collaborations between architectural firms, and assess the likelihood that such practice will develop into a fully-fledged mode of service delivery. In order to achieve these two objectives, the research was set out to answer three main questions. (1) What are the quantifiable advantages and drawbacks of offshore collaborations for Australian firms? Do they change according to the socio-technical characteristics of collaborating offices? (2) To what degree do professional and cultural elements affect the performance of firms engaged in the digital supply of architecture-related services? (3) Is there a way to quantify the cost of the transactions involved in distant collaborations, and use these costs as indicators of future geographic shifts in the procurement of design services? In the initial stage of the project, however, the main intellectual challenge was analytical. It concerned the organisation of a system of technical tests and design tasks that did justice to the complexity of the design process and the skills required to carry it out properly, whilst helping the researchers assess workforce performance and collaboration costs. Strategies adopted in selecting the sample of participating firms, and the choices the authors had to make in structuring ad-hoc pilots in order to collect meaningful and generalisable data are reviewed.

Keywords: Architectural practice, culture, distant collaboration, outsourcing, strategies

INTRODUCTION – THE REMOTE SUPPLY OF ARCHITECTURAL SERVICES

International flows and professional cooperation are not new in architecture. Most of the treatises that form its classic body of theory have been written by architects travelling on professional duty, and the whole epic of modern architecture was predicated upon a supranational thrust when not accompanied by temporary associations between foreign master and local technical cadres [Casabella 1996]. New, however, are the scale and pervasiveness of the phenomenon as it unfolds today. Over the last fifteen years, telecommunications infrastructure and digital technologies have converged to become cheaper and widely available around the world, defining an operative environment with relatively low entry barriers in terms of capital investment [World Bank 1995; Tombesi 2001b]. These advances have completely changed the modes of operation of the design professions, and drastically extended their territorial reach. Computer-assisted drafting equipment (CAD) is now used by the overwhelming majority of the design professions in advanced economies, and drawings are moved between offices for the most part electronically [Baker 1999; Dalal 2000; PMA 2001; Zweigwhite 2001].

The acquisition of geographic mobility has proved particularly useful to the profession of the western world, which has been able to service the industrial and economic take-off of non-western regions with low levels of urbanisation and subsequent low numbers of local building environment professionals. Architectural firms in Australia and North-America, for example, where the ratio 'design professionals-to-urban residents' is approximately 1 to 1,500 and the annual rate of growth of the economy sits at around 3%, have penetrated South and East Asia, where one architect serves a population of 15,000 to 50,000 people, and fulfills the building needs of GDPs growing by 6% to 12% a year [Tombesi 2002, 2004].

The unprecedented opening of international markets and the diffusion of digital networks, on the other hand, give the same architectural firms the chance to organise their geographic structure according to relative production advantages. These can be substantial when considering that the remuneration levels of the architectural profession reflect disparities in world wealth, and that labour costs reach on average 50% of office budgets. To the same employer, in 2000, an architect in the United States would cost twice as much as the same architect in Australia [Tombesi 2001a; Tombesi Dave Scriver 2003], ten times as the same architect in Sri Lanka, and fifteen times as the same architect in India. More recent studies show that such differentials have not changed substantially: offshoring work from the US to India, or from the UK to South Africa, for example, can still produce a ten-fold saving in drawing production costs [Young-Pugh 2005; Solomon Linn 2005]. If workforce relocation from higher-wage to lower-wage areas were viable, drafting (and possibly design) would be cheaper and companies' overheads reduced. This would be a difficult opportunity to pass up in an industry where, as Tilley [1997, 1999] and Gardiner [2002] have pointed out, internal professional competition is high, fee levels are either shrinking or dramatically inadequate, and returns are diminishing.

The 'industrial atmosphere' is in fact becoming increasingly conducive to establishing distant collaborations. The evidence of professional or business relationships involving firms from higher-wage and lower-wage regions is mounting rapidly [Housley Carr Krizan 1988; Korman 1995; Baker 1999; Klein 2003]. Meanwhile, the offer from lower-wage regions becomes more forthcoming, with whole lists of offices advertising the possibility for service collaboration on professional websites, and government agencies being set up to address, specifically, technological barriers to digital trade in architecture [Industry Commission 1998; Productivity Commission 1999]. In some cases, this is resulting in the concentration of IT infrastructure around specific, and essentially urban, locales – a strategy which gives such territorial enclaves a technologically competitive edge, favourable to the export processing of IT-related activities as well as the attraction of foreign investment [Tombesi Dave Scriver 2003].

The seeming development of an international arena for service exchange coincides with institutional acknowledgement and facilitation at international level. In the round of negotiations over the international supply of architectural services - which over sixty countries have entered since 2000 as part of the World Trade Organization's push towards the opening of global markets and the promotion of trade flows in the service industry (GATS) - many WTO member states have been openly considering the export of cross-border activities that rely heavily on digital communication channels, and are made competitive by low labour costs and office rents. [WTO 1998, Knapton 2000; Government of Canada 2001; DTI 2002; IIA 2003].

Recent analyses suggest that this type of cross-border trade can have major impacts over the geography of architectural employment. In the United States, for example, where the workforce of disciplines such as structural engineering has already been reduced dramatically by the relocation of 'routinisable' tasks, as many as 14,000 architecture jobs are expected to be moved offshore by 2007 [Madigan 2003]. In Australia, the impact could be even larger compared to the size of the economy, given the country's position at the centre of a much lower labour cost and yet economically connected region, its ability to transact digitally, and its pivotal role in the vocational training of South-east Asia's future workforce. If one applied the figures provided by the Australian Bureau of Statistics [ABS 1993] to the structure of practice delineated by the Royal Australian Institute of Architects - RAIA [Draganich 1998], and the rates of remuneration reported by the professional union association, APESMA [1998], Australia could experience the relocation of up to 6,000 jobs between architects and draftspersons, and a loss of 280 million dollars per year in local salaries[4].

[4] This estimate is only indicative and serves to give a sense of the order of magnitude; it includes non-principal qualified architects and non-qualified fee-earners from a technical population of approximately 20,000, working in firms with more than five employees and with over 80% of their revenues coming from non-residential work.

RESEARCH CHALLENGES AND METHODOLOGICAL SOLUTIONS

Although there is plenty of evidence that off-shore collaborations are well underway, almost none of this evidence can be put to effective use in a scholarly sense. To be meaningful, research of this kind must be concerned with the combination of hard technology and cultural conventions, and with the repercussions of this combination over the success of the collaboration. Yet most of the current discussion material is too generic, too anecdotal, or too narrow. Given the organisational heterogeneity of architectural practice, information about firm-specific experiences or arrangements is not necessarily transferable to the entire sector. Besides, very little structured information or technical descriptions exist on the actual mechanisms of these collaborations, their proven advantages and disadvantages, and the frequency with which they occur in practice or in relation to specific markets or tasks. Firm surveys must be taken with a grain of salt, in that they reflect an industrial paradigm still riding up its diffusion curve, rely on firms' voluntary participation in the collection of statistics, and do not provide descriptive or qualitative data about type of work, firm characteristics, and degree of technical or economic success of the collaboration. Last, macroeconomic or market indicators cannot alone provide empirical evidence of anything.

As Solomon and Linn [2005] note, the lack of openness and transparency about such arrangements is largely a result of the stigma associated to professional outsourcing/offshoring, and the fact that it encroaches upon money and profit, the most sensitive territories of practice. One should add, though, that the apparent secrecy is also a function of the level of fine-grain, cumbersome analysis necessary to draw robust pictures of the experience, and conclusions about its future viability. In order to be able to assess the real likelihood of technology-based job outflows in architecture and to structure policy responses, research depth and width are both required. Investigations must thus be carried out at a level detailed enough to allow meaningful engagement with the materials of practice. This can only be done by using individual firms as case studies. But case studies should also be structured in a way that does not require an infinite number of them. Limited sets of data, in other words, must acquire statistical relevance by providing findings generalisable to the entire sector.

In the design of this research project, an important decision was accordingly made early on to reverse the logics of the investigation. Rather than trying to define the current extent of the market - an almost impossible task - the research would attempt to assess the viability of distant collaboration arrangements in a hypothetical future given the structural characteristics of Australian firms. This would reveal whether or not the growth of this mode of practice is likely to concern specific types of firms, particular sectors of the industry, or none of the above.
In order to achieve this objective, the research program was set up as an 'industrial laboratory' where a series of controlled documentation projects involving collaborations between firms of different categories can be carried out, with specific indicators to measure the levels of technical proficiency required and the results obtained. In this laboratory, qualitative differences in the performance of distant actors can be examined, and the relationship between these differences and certain environmental characteristics be determined. The aim is to articulate the conditions that should be satisfied for Australian architectural establishments to outsource their work, and to determine whether or not the different types of firms involved in the market of digital collaborations at the moment have the technical capacity to meet the requirements identified. To this end, the plan of the research is to connect a group of six Melbourne-based architectural offices with four other specific, similarly-sized groups of theoretically competitive drawing

service providers, and have them work on the design and implementation of a collaborative project.[5]

Based on previous research a decision was made to compare the performance of four types of firms that cover the sociological spectrum of service subcontractors in architecture: (1) Australian firms that specialise in contract documentation, thus reflecting market niching decisions rather than socio-economic differences; (2) Indian professional firms, which epitomise entities active in a reality with similar historical roots but different socio-economic and environmental conditions [Tombesi Dave Scriver 2003]; (3) web-based firms, specifically set up to work remotely, without any programmatic connection to their physical place of operation and the direct result of technological opportunities; and (4) South-East Asian firms employing staff with direct experience in Australian education and professional practice, and possibly run by former Melbourne University students. The involvement of each group with digital sub-contracting is informed by different rationales and embodies distinct professional cultures: task-based, non-Australian place-based, technology-based, and place-informed (Figure 1).

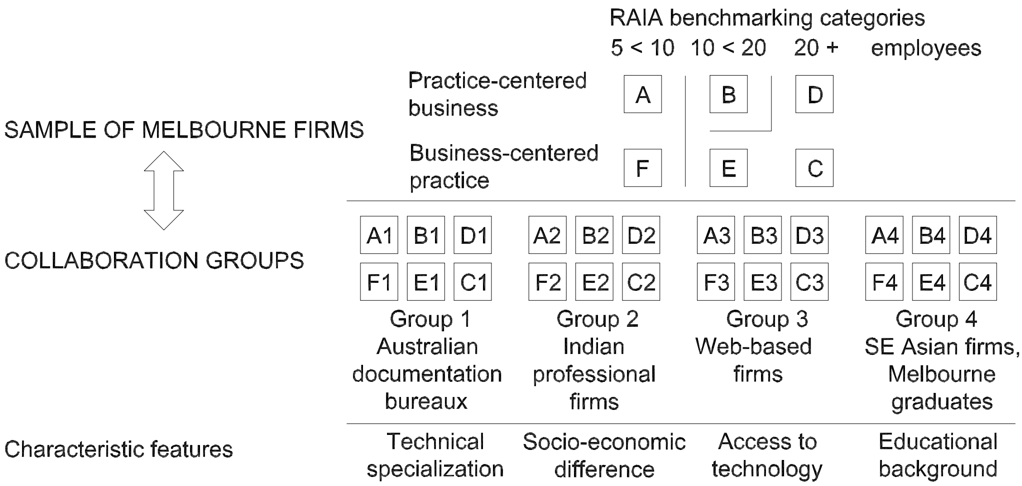

Figure 1. Conceptual organization of collaborative experiments

FIRM A		**FIRM B**		**FIRM C**	
Employees:	5	Employees:	15	E Employees:	45
Sector of Specialization:	Single Family Residential	Sector of Specialization:	Education	Sector of Specialization:	Multifamily Residential
Output % value of the sector in the building industry in Victoria:	42%	Output % value of the sector in the building industry in Victoria:	3%	Output % value of the sector in the building industry in Victoria:	13%
Architects % billings for the sector in Australia:	25% with **C**	Architects % billings for the sector in Australia:	14%	Architects % billings for the sector in Australia:	25% with **A**
FIRM D		**FIRM E**		**FIRM F**	
Employees:	70	Employees:	40	Employees:	10
Sector of Specialization:	Institutional	Sector of Specialization:	Healthcare	Sector of Specialization:	Commercial
Output % value of the sector in the building industry in Victoria:	6%	Output % value of the sector in the building industry in Victoria:	2%	Output % value of the sector in the building industry in Victoria:	18%

[5] It is worth stating that the organisation of these collaborations serves a purely research-based interest. It does not necessarily imply the authors' integral support of the mode of practice investigated. For a review of their position in this regard see: Tombesi [2001a, 2002] and Tombesi Dave Scriver [2003].

Architects % billings for the sector in Australia: 12%	Architects % billings for the sector in Australia: 12%	Architects % billings for the sector in Australia: 22%
IDEA–BASED	**SERVICE-BASED**	**DELIVERY-BASED**

Figure 2. Classification of the Melbourne-based firms selected for the project

The size of the original sample of Melbourne-based firms conforms to a widely accepted classification of the architectural profession into six categories: idea-based, service-based, and delivery-based organisations, further subdivided in 'practice-oriented businesses' and 'business-oriented practices' [Coxe et al 1987; Allinson 1993]. This classification captures the emphasis design offices of different size place on different elements - speed, innovation, research – and recognises the impact that these priorities have on their work methodologies, resources and number of employees. Since it applies relatively well to the industry data compiled by the Royal Australian Institute of Architects [Draganich 1998, 1999], it can also be used to describe a cross-section of the Australian architectural profession. The six firms selected - names and details of which remain confidential – have different dimensions and work focus: the smallest firm has 5 employees whereas the largest one has a workforce of over 70 in its Melbourne office. Two of them concentrate on residential development (single-family and multi-family), one on education, one on health, one on commercial structures, and one on institutional work. Two of them are part of the RAIA financial benchmarking Group 2 (5-10 people), one of Group 3 (10-20 people) and three of Group 4 (over 20 people), (Figure 2).

Operative details

The various inter-firm collaborations will be measured against a set of well-defined drafting tasks that make up the collaborative project, and which have been engineered to require (and allow one to observe) various kinds of technical knowledge and professional skills, including use of explicit and implicit conventions in building design and construction. Since this test allows the performance of each firm to be considered against known socio-technical characteristics, it will also enable one to understand the cultural factors that determine the successful resolution of specific documentation challenges (thus generating competitiveness in the market or reducing it). The research program will follow similar procedures to those in use in the market of distant collaborations, and will be carried out in four stages: project preparation, project documentation, performance evaluation, and application of findings.

Project preparation. The aim of this stage is to establish a baseline of expectations and costs. In conjunction with the group of six Melbourne firms that have accepted to collaborate on the research, we have designed the brief for a set of documents that reflect the nature of each of their practices and the markets they are active in. The scope of the brief includes representations at different scales, and comes from assembling schematic design and design development information already produced by the office for a finished building. It calls for two location-assembly-component-schedule drawing sequences and a total of eight A1 sheets. Each drawing in the list requires responses to the firm's specific language decisions (i.e. prescriptive technology), interpretation of code requirements (i.e. normative technology) and understanding of local traditions (i.e. conventional technology). Each firm has calculated how much the package would cost if produced in-house.

Project documentation. The twenty-four subcontracting firms selected for the project will be introduced to the task in the same way as it would happen in reality: through face-to-face contact for the Melbourne-based drafting firms, Indian firms and South East Asian firms; electronically for web-based firms. Each firm will be provided with background information (which includes sections of the client's program, site survey and report, selected schematic design drawings, office detail libraries, and particular system specifications), and asked to determine the price of the documentation work specified in the brief according to their fee scales and organisational structures. The information thus gathered will provide a preliminary indication of the cost differences between in-house and outsourced work, and a quantification of the savings theoretically achievable by subcontracting (Figure 3). Contact with one of the chief investigators and a project liaison of the Melbourne firm will only be maintained digitally. The documentation period will last approximately four weeks.

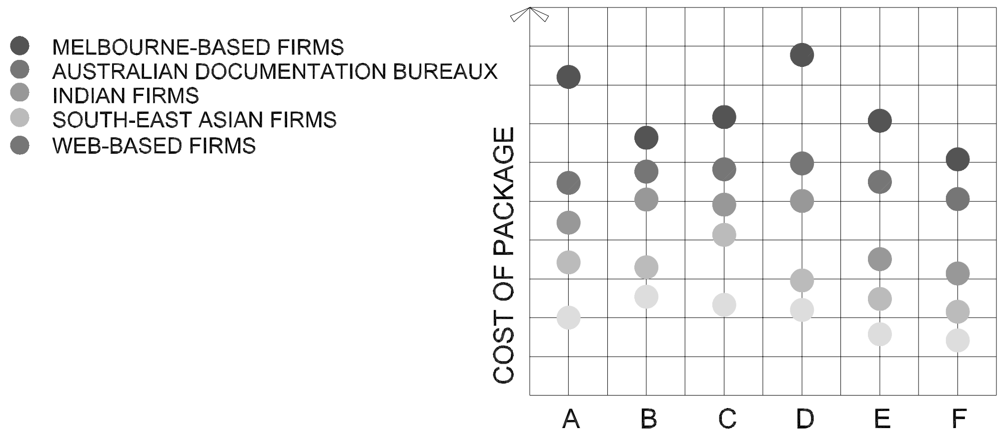

Figure 3. Example of comparative cost table

Performance evaluation. The documentation received will be evaluated in relation to the representational problems generated by the three types of technological systems in use – conventional, normative and prescriptive. For each type, we will consider a) understanding of design intent; b) correctness of notational codes; c) integration between scales of representation; and d) ability to track down inconsistencies. The performance of each contracted firm will be determined accordingly and translated into levels varying from 'unacceptable' (0) to 'superior' (5), based on the professional standards of the Melbourne firm acting as contractor. The results will be organised in diamond-diagram series to allow immediate visual comparisons between firm types. The third set of diagrams will also have an axis to quantify the ability of the documents to reproduce the professional culture of the architectural firm contracting the work (Figure 4).

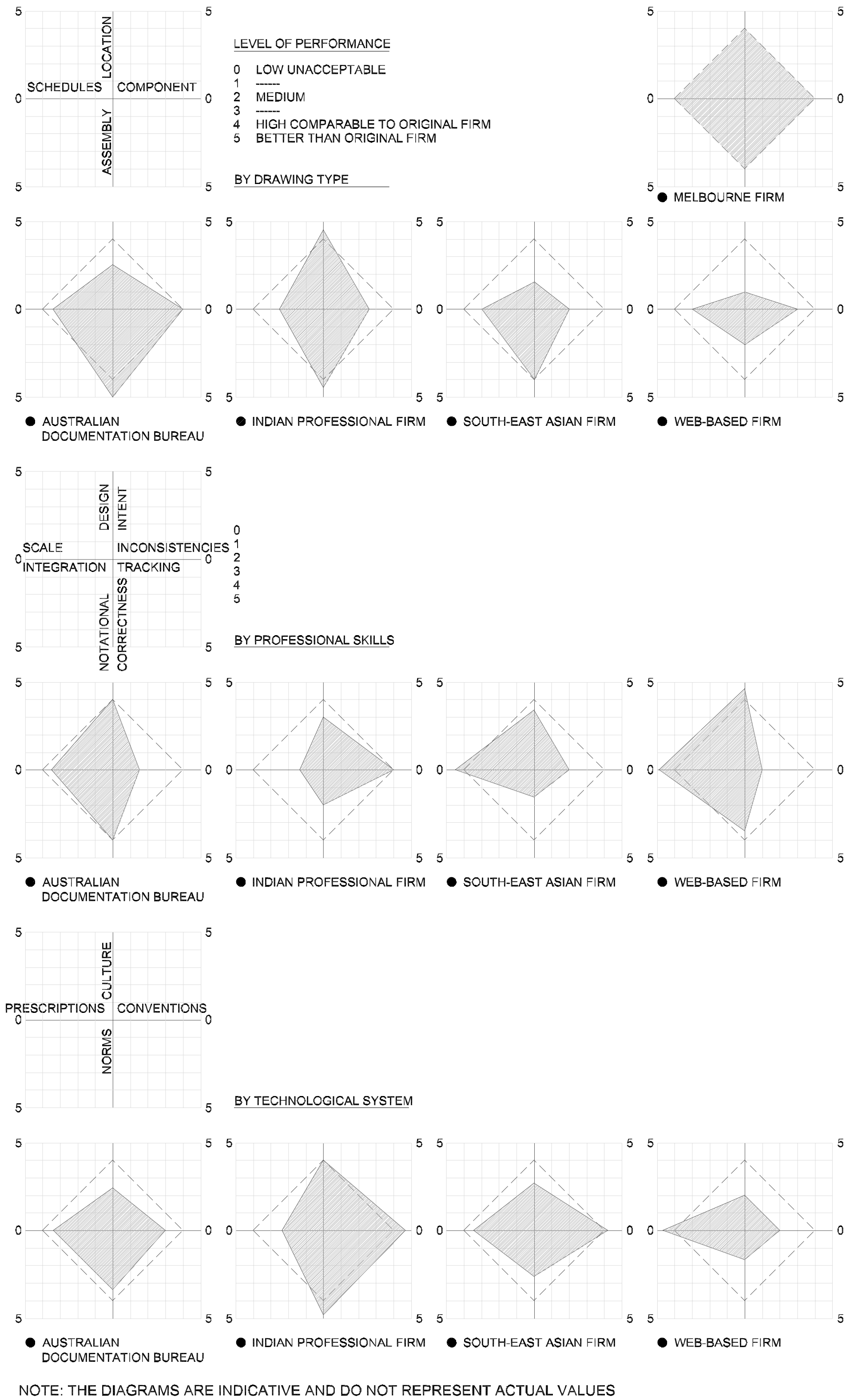

Figure 4. Example of comparative performance diagrams

The collaborative exercise will be repeated by using a much smaller and yet methodologically identical task after a debriefing period. The objective is to see the degree to which repeat work can improve the performance of each firm, overall or in specific categories.

Application of the findings. The preceding stages will generate a consistent set of data showing cost of the contract and savings obtainable through outsourcing on one side, and outcome of the work on the other. This information will be used to compare the relative performance of the four different groups against the requirements set by the six Melbourne-based firms (Figure 5). Since these firms were selected to reflect specific portions of the Australian professional market, it will be possible to determine for which sections of the profession (working on particular projects with particular technologies) digital collaborations with specific types of firms are operatively viable and economically sound.

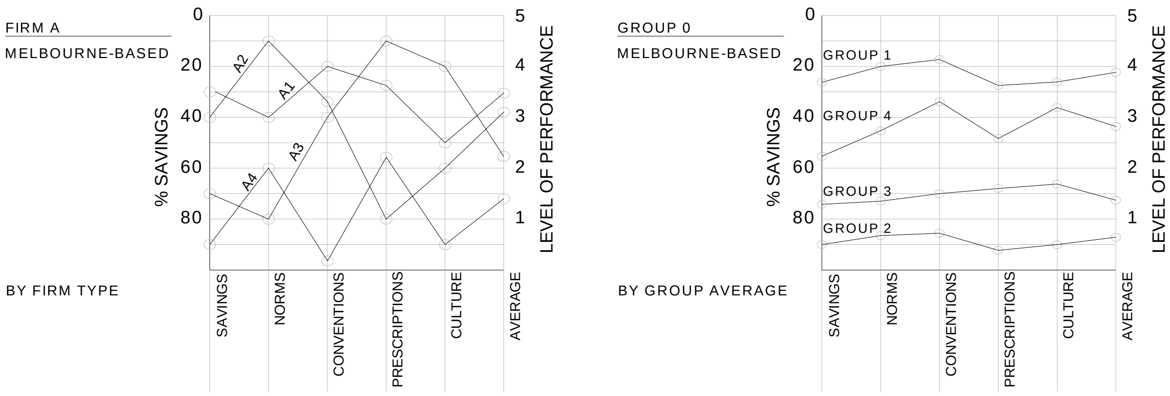

Figure 5. Example of comparative performance chart

IN LIEU OF CONCLUSIONS

A preliminary analysis of the data collected so far about the local Melbourne market and its architectural firms reinforces our belief in the methodological choices explained above. As expected, architectural firms appear to gravitate towards one or more selected areas of specialization and service delivery. They also tend to form alliances and collaborations for complementary services. Their practices appear to conform to and employ either explicit or implicit regimes of design procurement, decision-making, document production, and costing procedures, which indicate markedly specific collaborative needs. In the current phase of the project, we have selected the range of design simulations we want to undertake, and constructed a rationale for their local industrial relevance. The briefs for the collaborative pilots are being designed with the architectural offices, and will be used as a base for negotiation with the other four groups of firms in September. While the first results of these collaborations will be available at the end of the year, it will soon be possible to examine the differences in requirements between different types of firms and building types as they are reflected in the various requests for proposal. Although we developed and framed the project in the Australian context, we believe the methodological choices and operative details described here are applicable to most if not all professional regions around the world. We expect the results from this project to lead to a more systematic explanation of work variables in architectural practice, and their effect over service outsourcing decisions internationally.

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MANAGEMENT INTO DESIGN EDUCATION: A CASE STUDY.

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Abstract
The design project set in a studio learning environment remains central to much of the under-graduate curriculum activity for the aspiring architect. Yet much recent discussion has identified the need to look beyond this design curriculum horizon and to extend into studies in management. The Burton Report, among others, has encouraged diversity in architectural education. A degree course in Architectural Design and Management has been developed at Northumbria University as a direct response to this encouragement. However, challenges continue as students tend to see supporting studies such as management as peripheral, or even irrelevant and professional accreditation authorities seek evidence of performance via an academic portfolio only. Subsequently, management and professional studies in the programme have been developed as the process within which design happens and which allows a direct link into the studio programme. So, as for the professional practitioner, student design activity happens in teams, and has deadlines, studio design programmes have group projects and deadlines and these are structured with learning outcomes such as teamwork, timekeeping, and reflective learning.

Keywords: Management and professional studies, Studio design education.

INTRODUCTION
The purpose of this paper is to provide a reflective Case Study report on the early teething problems embedding a management curriculum within the BA (Hons.) Architectural Design and Management degree course at Northumbria University. This course is modularised but with a majority of large, design based, project modules delivered in a design studio. Additional taught modules, often shared with other student cohorts, provide for supporting curriculum, including some management modules. A balance has been sought between learning effectiveness and efficiency of delivery. The intention of the course, which began life in September 1997 and now has had 5 graduating cohorts, is to prepare the graduate for a wide range of opportunities in a rapidly changing professional context. It includes principles and practice of architectural design with management studies embedded within the student experience, underpinned by cultural and historical context, technology and environment, and the theory of management. The challenge has been in the implementation of such aspirations and to meet the conflicting demands of the quart in the pint-pot curriculum syndrome of appropriate design skills and knowledge development, introduction of new skills agenda (for example, keeping pace with the increasing use of computer aided design applications), and yet still introduce, develop and mature a major curriculum thread running through the programme of management studies.

BACKGROUND
The course was introduced as a direct response to the need for an expanded architectural degree curriculum as outlined in the Burton Report (1992) on architectural education to equip students for a wider role within a changing building industry and to provide an education in architecture for less specialised careers and as subsequently reinforced in the HEFCE Report on Architecture (1994). The underlying educational philosophy of the degree therefore, is in accordance with the principle of promoting degrees with particular emphasis on design, technology and basic management skills, as recommended by the CIC (1993), and is in line with current thinking from the RIBA which has encouraged variation in course provision. Graduates are to be able to satisfy the requirements of both the ARB and the RIBA, achieve exemption from Part 1 of the professional examinations and progress to further study towards an architectural qualification.

Consequently the design of the programme has incorporated the requirements of the Prescription of qualifications: ARB Criteria (May 2002) which have also been adopted and approved by the RIBA, the QAA Benchmarking Document (2000), and the EC Architect's Directive (1985).

History of Management provision

The course was originally set up within a University modular approach, with two management modules (out of 12) in year 1, a core management module and an optional management module in each of years 2 and 3. At the time, the University ran a core plus option policy. The other options offered were computing and language, and the first cohort of students, with one exception, opted for computing. Even though the students had chosen the programme with its unique combination of management and design, it would seem that they prioritised their options for modules that they believed would be most useful in getting a good degree, and getting a job. It also became apparent that the modular approach, with little direct link, at the time, between the taught management programme and design projects, was resulting in the students having difficulty in engaging with management as a subject.

Consequently, potential links between management and design teaching were examined, and a proposal to introduce a management portfolio, assessed within the design project portfolio, was made. Management issues were initially related to design through reflection on process, and to time, cost quality and health and safety issues. First year have a reflective log, while Second and Third year are directed to consider specific issues related to projects. A key aspect of the Third year is the preparation for practice. The lecture programme deals with the process of procurement and related issues, such as planning and building regulations. The process is related to the first design project, and students have to produce a feasibility study report for their own design, to include regulation, timescale, appropriate procurement and construction process. The students gain a genuine insight into the process by which a design is realised and is invaluable for them. They also undertake a management related research paper, which gives them the opportunity to investigate a topic in some depth. Papers have varied from PFI to self-build housing.

Pressures

There have been significant pressures on the management aspect of the course:

- Student perception: This has been addressed significantly by the introduction of the management portfolio. The introduction of portfolio sheets into projects giving details of regular interim targets also encourages the idea of architectural design as a managed process.
- Modular programme and pressures to share modules developed for other programmes to fit timetable constraints: A module in economics was taught jointly with the construction management students in second year, but was at an inappropriate level for the architectural students, and was dropped.
- Development of ARB / RIBA criteria. When the course was developed, there was encouragement for diversity, and Architectural Design and Management was one of a number of courses that were proposed. However, increasing concerns expressed by the ARB regarding the competence of graduates at Part I, Part II and Part III, led to the publishing of Criteria for Prescribed courses, which is constraining diversity.

Management in the Curriculum – an evolving picture

The course aims for the management curriculum have now emerged as:

- Engage in the challenge of management in the discipline of architecture, which is conducted within a professional and commercial business environment.
- Understand the process of design within a wider industry perspective.
- Develop an increased self-awareness within the discipline.

These strategic aims have been articulated into specific modules as:

First Year Module
Management Principles, Practice and Communication.

- Roles within the Built Environment professions.
- Sources of finance.
- Non-visual communication in terms of research, report writing and presentation.
- Forms of communication.
- An introduction to management principles and theories.

Second Year Modules
Management Skills.

- Management skills within teams.
- Leadership styles, models of task / individual / teams.
- Team working.
- Communication – needs, styles and methods.
- Effective use of time and energy, meeting deadlines, working under pressure, understanding and managing stress.
- Decision making techniques, creative thinking techniques, lateral thinking, allocation of resources, making decisions in conditions of uncertainty.
- Negotiation and Conciliation.
- Resolving conflicts, handling disturbances.
- Selection Interviewing.

This module includes the management in action field trip, which allows the student to experience group and individual challenges of action, problem solving under pressure, design brief communication, and task management and which culminates in a raft-building task.

Structural and Spatial Design.
This module offers an opportunity to analyse the processes and products of design in the Built Environment, an integrated approach that enables the students to apply the strategies learnt in the module in their design projects. Students develop their own design methodologies based on analysis, synthesis and creative application within an assignment related to a design project.

Final Year Modules
Architectural and Design Project Management.

- Key issues in the management of a project at all stages of the development cycle.
- Procurement and administration of a project and its control on behalf of the client.
- Skills base in project management and practice management.
- Underpinning theory to design projects.
- Implications of health and safety issues on design practice.
- In-depth study which is substantially student driven, by the investigation of a defined subject area, illustrating critical analysis, evaluation, discrimination and objective balanced argument.

Professional Practice

- Project Management Overview
- Project Management Processes
- Health and Safety in Design
- Practice Management
- Contract Management

- Feasibility study of a previous design project to include planning and procurement.

Research study

- Structuring and writing research papers:
- Hypothesis, aims and objectives, methodology, literature review,
- Data collection and interpretation, case studies, analysis
- A topic selected from a list looking at the process of architecture.

Management within the Design portfolio.
Management is also embedded within Design Project modules. The First year includes a reflective log and the Second and Final year Project modules now include a management portfolio. This is assessed as a pass / fail element – the intention being not to detract from the assessed Design content and also not to allow completion without a student passing this section of the module. The management portfolio is seen as the essential way to engage design-focussed students with management issues. It builds on the work of the first year management programme and moves from reflection to directed studies in the second and third years. Students are asked to consider issues of time, cost, quality and health and safety; personal and interpersonal issues such as team-working and time management; and brief-making, in the context of their projects. So, students may provide simple bar charts showing their own personal programme for producing their design on time, a notional bar chart suggesting a construction time-scale, a simple cost calculation, assessment of safety issues on site or within their design project, reflections on team-working, or a range of other simple exercises relevant to the nature of a specific project. These elements build up as a portfolio of material, which supports and is clearly seen as a part of the design portfolio. The third year architectural project management assignment, a feasibility report to a client written on completion of their first design project, is also seen as an important link with the portfolio.

Support
The management curriculum thread has received strong support from the validation body, students and employers. The RIBA Visiting Board Report (2004) provided recent strongly encouraging supportive comment such as:

- "The integration of management issues into the design process, such as leadership, project management, decision making, team working between and within professions, was exemplary and should be considered as a model for future consideration elsewhere."

The Report also noted that the students were supportive:

- "The students believe the additional knowledge and skills provided by the management component of the course are advantageous when applying for jobs and assists them greatly when in post."

and

- "The students believed that the course prepared them well for entry into the profession. They valued the contribution made by local practitioners. Students considered that this, and the integration of the management component, effectively gave them a head start when entering practice, as they had acquired additional knowledge about the realities of practice."

The Report also commented on a meeting held during the visit with local employers of graduates:

- "The practitioners … believed that the management emphasis of the course enabled students to enter practice much better prepared for the realities of the workplace. They were grounded in their attitude and approach, time management skills were excellent, they were quick to grasp ideas, responsible and pro-active. The practitioners stressed that none of this had been attained at the expense of design skills." One employer, a director of a

> major local practice said “we have found that the students from Northumbria University demonstrate a better understanding of the building process thanks to the management aspect of the course … students from Northumbria University have skills relevant to working in practice.”

UNDERPINNING PRINCIPLES

Studio based education does remain a central feature for design students. It is not the purpose of this paper to provide a defence of the design studio as pedagogical practice. We accept that the design studio provides a unique and special learning environment for the student with a “hands on, learning by doing” approach to learning. This approach is also being looked at by other subject discipline areas as an effective pedagogy and where the place and need for the traditional lecture theatre approach to learning is being challenged as only a place of transfer of information where perhaps, a surface approach to learning can only exist (the debate is much simplified to make the point). For example, Carlson and Sullivan (1999), argue the case for a hands on approach to engineering education where student involvement is a key feature, they suggest, that can lead to deep learning. Entwistle (2001) likewise suggests that student learning style preferences must be taken into account and that the pedagogical strategy chosen by course curriculum designers must match the learning needs of the student – a further argument for the design studio. It is, by definition, also providing active learning (the learner is doing), rather than passive learning and to move from just articulation of knowing and understanding into higher learner empowerment (and employment) levels of application and testing (i.e., thinking outside the box) and can with subsequent appropriate commentary and critical analysis seek innovation and improvement of practice. The conclusion being that the student can become aware of good and accepted practice but also motivated and prepared to seek improved practice – surely the need of the modern workplace?

However, it is not without its’ challengers. For example, Schon (1985) has argued, and Brown and Moreau (2002) further graphically illustrate and support with their paper ‘Finding your way in the dark’ design students are confused and mystified to be asked to design without really understanding what it is they are supposed to do. Perhaps a mini-synopsis of the pedagogical dilemma that many course providers will struggle with – how can students be expected to design a building or an artefact without understanding the essential ingredients that come together to make up the whole?; likewise, with management in the curriculum. The difficult balance to be reached is to create a curriculum that provides necessary underpinning knowledge and understanding yet still provides context and application (with student engagement and motivation being perhaps a subsequent useful bonus!).

Stepping back from this detailed argument for the inclusion of management in a design curriculum and the subsequent challenge of how best to do this, recent conferences looking at design studio educational practice (Studio Culture: Who needs it?, 2003; Studio Culture 2; Touching the Real, 2004) have argued for a tangible, reality of learning experience that is more than just transmission of knowledge (the lecture theatre experience?). For example, Till (2004), in his keynote address to the Studio Culture 2: Touching the Real conference, made strong reference to the seminal work of Freire (1972) who argued that learning can be a set of practices which have the potential either to empower (by enabling critical analysis) or disempower individuals (by merely reinforcing existing unequal relationships within the community). If learning only involves the transmission of knowledge; that is, from a knowledgeable person to the learner then under this banking approach to education, the danger exists that (Freire, 1972) -

> “the teacher talks about reality as if it were motionless, static, compartmentalised and predictable, and fills the student with contents that are detached from reality, disconnected from the totality that engendered them and could give them significance.
> the learner brings little to the learning situation except the capacity to absorb and recall.”

There is also the unavoidable materialist aspect of education from the student perspective. Investment of student effort, money and commitment will often be gauged against a return – whatever they may be – a high grade, a good job – with the student the sole arbiter! Learning, in this pedagogical paradigm is not learning out of interest, but learning for a reason – a return on investment. Perhaps a secondary, but still crucially important, issue for the student is the role and complex influence of the design-assessing tutor during critical reflection and assessment of work. Assessment criteria explicitly communicated or implicitly implied (often described as the hidden curriculum, Dutton 1991) will often drive the student agenda and as such may restrict or limit learner empowerment. There is indeed much to be applauded for the work that takes place within the design studio. The learner is placed central to the learning experience.

REFLECTIONS

It would seem that the content, style and ethos of the course receive good support. Beyond initial public domain rhetoric concerning curriculum diversity, is the unavoidable reality check that the course team of tutors and the students have to live with and accept; that is, this is a design degree first and foremost, a fact that cannot be escaped from. For both tutors and students, the reality is that the combined pressure from the Subject Benchmark Statement, the RIBA and ARB requirements, the student looking ahead and anticipating good employment prospects, all combine overwhelmingly to dictate that design ability is the key, bottom line essential ability that the student needs and cannot avoid. It is against this background that the course tutors firmly believe that management curriculum, if it is contextualised and integrated into the practice of design adds real value to the student learning experience and allows the student to become a more effective, more efficient and a more informed designer.

We therefore choose to treat management and professional studies in the course as the process within which design happens, which allows a direct connection into the studio programme. As in professional life, design activity happens in teams, and has deadlines. Studio design project programmes have group projects and deadlines structured with learning outcomes in teamwork and timekeeping. The management teaching supporting the course deals with interpersonal skills and teamwork, so there is a body of knowledge that the student can use to reflect upon the process.

Our experience suggests that by the Third year, the students do relate these skills to project work, and find their knowledge extremely valuable when they graduate and enter practice. By having a working knowledge of the context within which the core activity of design happens, they engage very quickly in work, and employers feel that they can contribute quickly to the office, and learn much more themselves. One employer has said of one graduate of the course "…it has been observed consistently that his effectiveness is significantly enhanced by a broader appreciation of the context of the tasks in hand combined with a proactive and enquiring mentality. Wesley has in consequence more capacity to work independently than we would usually expect for someone at his stage. We put these characteristics down to the influence of the management and real-world related aspects of his training."

CONCLUSIONS

This paper is limited in that this is a reflective report on only a single case study. It may be that experiences gained putting together and implementing such a degree course are too narrow and are not transferable into other academic environments. They are, however, real experiences which may usefully be shared with colleagues. Real lessons have been learnt and where change and modification have been seemingly never-ending over the last few years as a formula has been continuously sought in the pursuit of successfully embedding what at first sight appeared to be a second-stream subject into main-stream activity. Our main conclusions from this case study experience are:

1. A diversity agenda will not work. Students may, from their free choice, diversify later in their careers, but for the purpose of attaining an undergraduate degree in Architecture which meets all the established criteria, the unavoidable student focus contained within the timescale of this 3 year study programme is on design capability and design employment.
2. Split or combined award undergraduate degree curriculum for such specific professional and vocational degree course does not work. It challenges the student to reach minimum threshold standard ability to successfully become a practitioner. Concentration of effort is required on core curriculum.
3. Management can be successfully embedded with a design curriculum with a careful balance between a taught and a shared curriculum. It is also essential for course tutors to *own* the management curriculum agenda, for it not to be sub-contracted out, and who as professional practitioners can understand and relate to the need to embed good management practices with the design process.
4. Management curriculum must be contextualised into the process of design.

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HOW ARCHITECTURAL EDUCATION IN SWEDEN SUPPORTS THE ROLE OF HANDLING USER INVOLVEMENT IN THE BUILDING PROCESS

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Abstract
The architectural skill of designing the right product that will function well for the future user requires an efficient dialogue with the user; which is an important argument in favour of involving users in the process. This paper deals with user involvement and how it can be strengthened through a change in focus in architectural education. The paper builds on the author's licentiate thesis "User's requirements in the building process" (2005) in which some questions about the role of architects were raised for further debate. Who is the professional actor who can guide and support the users when they formulate their needs and requirements? What knowledge is needed to take the pedagogical role of explaining the complex process for the user? The architect is often given this role as guide to the user in addition to the role of designer of the project. In this paper I will present the state of education in schools of architecture in Sweden and discuss how to find the right tools to operate effectively in current working practices.

Keywords: Architectural education, inclusive design, user involvement,

INTRODUCTION

Laws, regulations and environmental goals give a framework to the design process. Planning for a sustainable and robust society strengthens the aim of designing for all people. In 2010 all public areas must provide total access. This gives us an opportunity to raise our competence and expand our innovation in areas connected to the varying needs of all clients and users. The expression "democratic design" embraces the requirements for good design that takes into account disability, health and safety. It is also possible to add a social dimension to building design and urban planning. This may be is an important issue for architects to reclaim after some decades focusing on such other issues as lean production and aesthetics. Good knowledge of economic calculations is also needed to support decision-making in the early stages of the building process.

BACKGROUND

The architectural skill of designing the right product that will function well for the future user requires an efficient dialogue with the user; which is an important argument in favour of involving users in the process. In the licentiate thesis "User's requirements in the building process" (Svetoft 2005), some questions about the role of architects were raised for future debate. Who is the professional actor who can guide and support the present tenants when they formulate their needs and requirements? What knowledge is needed to take the pedagogical role of explaining the complex process for the user? The architect is often given this role as guide to the user in addition to the role of designer of the project. In this paper I will present the state of education in schools of architecture in Sweden and discuss how to find the right tools to operate effectively in current work practice. Focus is on user involvement and how it can be strengthened through, for example, a change in focus in architectural education. One basic question to deal with is whether there is any reason to work with the user's involvement in the building process. In designing a work environment in a company there seem to be positive effects both for individuals and the organisation. In the doctoral thesis by Lindberg (2000) "When good intentions meet reality", several effects are described. A cooperative design process makes it possible to take a step towards creating a learning organisation: new knowledge is developed and a common "language" is given to the co-workers in the organisation. An important "We" spirit can be developed in the course of formulating the needs and requirements for the future work situation.

THEORY AND EXPERIENCES

Good quality, or a better expression, right quality, can also be an interesting argument in the building process because of the large scale of resources and money involved. For the real estate owner a user's involvement can bring about positive long-term economic effects. Bergman and Klevsjö (2001), describe several arguments, models and tools for the important work of putting the customer in focus. A better quality also has an impact on the company's earnings. The content customer comes back and requires fewer resources to the company due to small costs for product changes and so on. Customer-focused planning and design in a Japanese model is also described as a developing process. It seems necessary to work this way in order to be able to take the next strategic step in a changing world. The best strategy is to know all about expectations and needs even before customers know these them themselves.

When looking at development of products other than buildings, customer-driven processes are more often used in the design of new products. It's useful to have a dialogue during the creative process in order to get as many guidelines as possible before production. In the case study of Campus Östersund (Svetoft 2005) there is a discussion about the importance of having a clearly articulated goal if the aim is to work with the user's involvement. In this case both actors of importance meaning the real estate owner and university were very clear about the aim of the project: The personnel at the university were invited to participate in the process with support from the actors involved. Involving users takes time, and the need for resources is obvious, because time represents money, especially in the building process. The professional team of architects and engineers have to meet the users and discuss their requirements and then translate these into drawings and plans.

Lack of knowledge is one problem when involving users. According to Schéele & Rundlöf (1998) there are some barriers between different areas and actors that must first be surmounted to be able to integrate the necessary knowledge and action. They also talk about cultural differences that can hinder communication. If the user does not even know what kind of knowledge is needed participate in the process, there is a problem. The professional architects must also be willing to involve the user and to develop a clear understanding of the user's situation. An interesting experience reported in several case studies made by Elisabeth Hornyánsky Dahlholm (2000) is that, in being involved during the design process, the users themselves became more aware of their own priorities and values concerning living/working. They also expected the professionals to respect their point of view due to their increased understanding. Related to this phenomenon a user may expect the architect to accommodate his or her personal preferences to a greater extent than usual, which may present problems for the architect. Involving the user in the building process raises questions about relations connected to roles and power, knowledge and competence and about who is responsible for the decisions. The architect must reflect on how to communicate. Both the architect and the user must have trust in the process.

AIM AND METHOD

When working on my licentiate thesis I followed and attended all the project meetings and I also had time to reflect on the roles of the actors. The architect has the opportunity to take the role as the pedagogue who can guide the user through the process. The problem is that no one actually gives this mission to the architect. When handling user involvement in large-scale projects involving large companies or organisations, there also seems to be a need for several other competences. Knowledge about how to handle people and their reactions and interactions in the changing process can be useful in this ongoing parallel process. Planning and moving into a new building causes different individual reactions, and it is good if this can be held out from the building process and made more efficient. The most difficult decisions may be around the question of which actors to involve in the professional team. In today's working conditions, the trend is to have fewer people doing more work, and taking on more varied roles, and sometimes it's hard to admit one's lack of competence in particular areas.

Based on my own experiences when working as an architect and reflections during the case studies, it is clear that there is a lack of knowledge among users about how to create and produce a building. This fact slows down the process as different actors have different levels of understanding of what is going on. There also seems to be a big difference in how to translate several basic expressions used in the building process. On several occasions is has been apparent that there ought to be more knowledge about how to open up a discussion in order to formulate user's needs and requirements. There are so many different kinds of people with special needs due to different disabilities or other factors related to wellbeing, yet these are very poorly described in the literature. As an architect I have discovered that my "expert-knowledge", even if it is delivered with the best of intentions, sometimes doesn't match conditions encountered in a given "real- world" situation. After some years experience may teach you how to handle certain situations but you still have not got solid tools to better address these situations. During the course of education there is a great opportunity to learn more about dealing with "nonprofessionals" regarding the building process. The tools can be given to students during their time at the academy. When studying architecture at the University of Lund from 1980 to 1985 we had some lectures about the user's needs and the function of a home. There were some lessons led by the teachers at the Department of Building Functions Analysis where we worked in a fullscale laboratory. This gave us a better understanding of how plans should function in real use. It was very useful and created a new understanding and attitude towards the issues of work and responsibility in creating the environment surrounding people's everyday lives.

Method

Architectural programmes are offered at three universities in Sweden. Reading the descriptions of the education programmes on the websites of the University of Stockholm, Chalmers and Lund reveals some different formulations about architectural education and the former role of the architect. It is also possible to view details of various courses and see the content of the education. The difficult part is to really know how the teachers handle the task of guiding students through the programmes. Teachers with work experience can give a lot of extra knowledge to the students about how to involve the user. The overview is based solely on the official information at the websites.

EDUCATION IN SCHOOLS OF ARCHITECTURE IN SWEDEN

Descriptions of the programmes offered by the three schools of architecture in Sweden today give an interesting picture of the education and the role the architect is expected to take. A general description of the architect's working situation will be followed by a description of the architectural programme of education. As a third theme there is an overview of courses that addresses the issue of user involvement in the building process. The following figure (*Figure 1)* presents a list of the architectural programmes at the three universities in Sweden is presented.

	The Working role	The Education	The courses
KTH University of Stockholm	Deal with complex and changeable systems	Offers a holistic point of view	Explore architectural possibilities and limitations
Chalmers University of Gothenburg	Ability to incorporate various aspects	Acquaints students with the architect's tasks and methods	Give basic knowledge about the architects' working methods
LTH University of Lund	Understand the relationship between humans and the built	Aims to produce creative architects able to identify and solve problems	Encourage consideration of different perspectives

	environment		

Figure 1

General description of the architects working situation

KTH: "KTH School of Architecture offers a programme integrating art, technology and social science. Architecture has an indisputable position in a cultural context. Its importance in the social debate is increasing along with the growing importance of design a cultural and economic growth. Architecture is however a much broader subject than colouring, facades and disposition in space. It deals with complex and changeable systems depending on and emerging from larger number of aspects."

(A translated version of the Swedish description): "As an architect you will work with development of the future society taking a broad perspective. You will use artistic, structural and technical skills to design interiors, buildings, towns and landscapes. It involves drawing dwellings, official buildings, offices and industries, or to working with renovations and reconstructions. Architecture has a great cultural and social importance which gives contacts with and knowledge about several sectors in our society. The job market fluctuates according to the market."

CHALMERS: "Many architects in professional practice work with the design of buildings and building interiors. Others work to develop the existing building stock. Still other architects work with community planning or research and development. Common to all of these fields is that they require the ability to incorporate various aspects, interests, and knowledge into a unified whole. Architects must be able to oversee and respond to technical, economic, legal, social and aesthetic aspects, and they must be able to work together with others."

(*A translated version of the Swedish description*): "The work of the architect goes beyond just designing buildings. When they hear the word "architect", most people think of the architect that designs buildings. But architects work in a wide variety of areas: designing cities, parts of the cities, buildings and interiors, as well as research and development activities. If your goal is to leave your mark in society, you should know that the architect who plans a community has as much impact as the architect who designs a building! It is also important to have architectural competence among the real estate owners. It is here that the frames are given and ideas are tested towards the interests of the common society. The work of architects who are involved with the real estate business, focusing on reconstruction and extension of the existing building stock is also of importance. It is easy to "sink" a building if it's changed unwisely."

LTH: "The process of designing buildings and the built environment implies giving a functionally correct and artistically conscious form to building and urban districts. In order to do this, the architect must have knowledge in many different areas, and be able to understand the relationship between Man and the built environment."

(A translated version of the Swedish description): "Technology and Aesthetics with people in focus. As an architect or an industrial-designer you are working in the interesting borderland between Technology and Aesthetics. A large portion of your working involves the issue of shaping the everyday products, environments and systems surrounding us, whether the task is planning cities or developing new products or concepts. To do this one requires strong knowledge in many different areas in which a central issue is the relationship between humans and the physical environment or technology is a central issue."

Description of the education
KTH: "KTH School of Architecture offers a programme integrating art, technology and social science. The schools of architecture have a special position since they are regulated by an EU directive from 1985. The architect's profession is carefully regulated in most countries and the directive guarantees that those whose education meets the requirements also have the right to freely carry out their profession within the whole EU/EES area. This adds to the special demands put on the schools; in Sweden more and more companies and architects get involved in international commissions and in these cases it is of utmost importance to have qualifications which meet the architectural directive. The architectural educational programme offers a combination of courses and project. Each year commences with an intensive course in, for example, architecture and theory and other subject areas are also integrated into the education, such as architectural history and building technology. In addition, there are subjects such as watercolour painting, sculpture and drawing through all the years of the programme. However the main focus rests above all on a number of optional projects the first of which is introduced at a very early stage. These projects develop in size and scope from short and strictly defined tasks to longer and more independent ones involving more and more complex application tasks. In these projects the students are faced again and again with the task of designing architecture projects themselves, in continuous dialogue with their teachers. The project work is both a way of acquiring knowledge and skills and a way of acquiring the architect's work method, developing skills such as sketching; and continuous questioning and development, whether for a small one-family house or for a complex city plan. Within architecture, there is never a single given answer to each task there are many possible more or less good solutions."

(A translated version of the Swedish description): "The central topic is architecture. You will solve architectural tasks in integrated studies in the form of projects. In the beginning the projects are short and limited in scope; as the programme progresses they become more extended and more complex. In addition to the projects you will read architectural theory/history, design and project management, design and you will perform some art tasks. The first three years contains the basic courses, the same for all. During the fourth year you can choose between different programmes. In the fifth year you can attend a variety of courses on theory and methods and finish the programme with an examination paper. The education is broad and will give you a holistic point of view, knowledge about configuration and insights about architecture.

CHALMERS: "The Master of Architecture Program is a five-year pre-professional course of study incorporating technology, social sciences, and the arts with a primary concentration on the planning and design of buildings. The first phase of the Master's Program is a core curriculum of six terms of compulsory courses and projects combined with blocks of theoretical and concentrated studies. Thereafter follows a second phase comprising two terms of elective courses.

(A translated version of the Swedish description): "Within this programme a number of architects will participate as guest teachers or assistants. They come from our prominent architect offices here in Gothenburg and from various cities in Europe. They share their practical experiences and teach you the importance of starting with the actual reality of construction and use, which is very important for us here at the University of Chalmers. During your studies you will become acquainted with the architect's tasks and methods. You will learn computer-programmes such as AutoCAD and 3D Studio, drawing everything from interiors to city plans. You will also learn how to contribute to a sustainable development of the society. You will have courses in architectural history, building materials, construction, sketching, painting and sculpture. An important part of your education is learning to see with the "architect's eye"- and paying attention to what in the building and the environment is important for expression and function. You will also follow developments in international architectural."

LTH: In the main goals for the programme there is an explicit aim to give the students skills and abilities to plan, shape, manage and renew environments and buildings with an overall concern for all people and the society. Linked to the EU directives, the students will also achieve an understanding of the architect's profession and tasks and how to meet the user's requirements within the frames of economics and regulations. "The analysis of buildings and the built environment, and an understanding of how they have been formed is what the students will learn in the programme in Architecture. With this understanding and good examples, visions of future environments can be developed in their entirety and in detail. The aim of the programme in Architecture at LTH is to produce creative architects able to identify and solve problems in the fields of architecture and town planning. The programme is both artistic and academic, and provides a comprehensive education dealing with spatial design and theoretical problems. In the 2001 term, a new syllabus was introduced. This is divided into 3 years of basic education and a final period of advanced studies for 1 year, with the possibility of a 6- month extension. Students are free to choose between a detailed area of specialisation or a broader, more general, course of advanced studies."

(A translated version of the Swedish description:: A big part of the education is working with a project with strong connections to real and actual question. External organisations and companies often participate to create a realistic situation. You often work with expressions such as "concept", "identity" and "form and function" setting out the conditions for the task, which might include analysis and shaping an environment, an object or a place while keeping the human being in focus.

Courses addressing issues of user involvement
KTH:
Architectural project 1:2 : Planning multi-storey buildings and the individual room.
Architectural project 2:1: deeper studies and understanding of housing by studies in programmes, places, rooms and scales and by analysing needs, study materials, constructions and measures with the purpose of examining architectural possibilities and limitations.
Architectural communication: seems to be more about developing the students' own skills in expressing themselves by using artistic tools rather than communicating with others during the building process.

CHALMERS:
The courses during the first year contain basic knowledge about the architect's working-methods and different working and competence areas. Shaping the room and theory of design combined with studies in built environment are two central parts, which are supplemented with architectural history and building construction.

LTH:
The first two years provide project work and integrate a number of courses which present the student with a possibility to consider different perspectives including aesthetics and spatial, functional, technical and ecological factors. The Department of Building Functions Analysis presents the subject of the built environment and how it is designed, how it is used and how it changes. The user perspective is essential for these basic questions of knowledge and communication when they participate in the design-process. The students also have opportunities to work in a full-scale laboratory. The department of Environmental Psychology gives a course on the subject: "Humans, the Psychical and Social Environments and Their Interaction". Areas introduced to the students include special needs for an aging population, special environmental factors such as influence of light on humans and the psychological effects of colour, noise and temperature, and how these affect mental performance.

DISCUSSION

In the general description of the architect's working role none of the schools describes the pedagogical role that must be taken on when the user is involved in the building process. In the more detailed descriptions of the schools' programmes, differences are apparent in how much each school focuses on the user. KTH describes Architecture as the broad subject which deals with complex systems depending on and emerging from a large number of aspects." The communication skills that are provided gives insight into how to handle the methods and tools of the architect to express his or her ideas. Chalmers describes the need to develop the ability to incorporate various aspects and interests into a unified whole. The ability to work cooperatively with others can mean working successfully in the professional team with different engineers and consultants. The school in Lund has the most explicitly stated ambition with respect to addressing issues concerning user involvement in the building process. The description talks about developing products and environments for everyday use with the human being in focus. Here the technology is focused more directly on the needs of the user than on the development of the product.

All the teachers and assistants involved in architectural education contribute to the students' knowledge when they describe the architect's way of working and their own experience in the building business. My opinion is that the role to guide the user through the building process could be more clearly stated. It seems that the skill to express one's own ideas has priority, over the task of formulating needs and requirements in cooperation with the user. The Swedish Association of Architects is working with the possibilities of a more international role fore architects. Due to this, they think it is important to claim a broad and responsible role.
They have listed the most important goals for architectural education and several aspects of the user are mentioned. Both in a theoretical and practical sense it is important to understand the role and to have the ability to meet the needs of the user within the frames of economics and regulations. The student architect must learn to consider the needs both of the individual and the society in a sustainable development.

According to the case studies made by Hornyánsky Dalholm (2000) some architects may feel threatened by the prospect of involving the user in the design process. Such involvement may be seen negatively by architects as interfering with their work, and as reducing their space to create something with only their own ideas. The attitude towards the users and the responsibility of the architect can be discussed during the course of architectural education. Which methods and tools can be used to decrease the communication gap between the user and the professionals? The schools today have good opportunities to be part of a positive development in this issue. For example computer -aided programmes can already be used in education to support the students participating in creating new methods and in conducting ongoing research work in this area.
The schools also have a huge responsibility and ability to give students a good perspective on the future role of the architect. Initiating a dialogue and discussion about this issue can also contribute to comparing the role in a wider perspective and helping students from different countries to develop a future role with an international perspective on user involvement.

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