Design Communication and Collaboration

Rudi Stouffs,[1] *Jan Kooistra,*[2] *Bige Tunçer,*[1] *Evren Akar*[3]
[1] Chair for Technical Design & Informatics
Faculty of Architecture
Delft University of Technology
r.stouffs@bk.tudelft.nl, b.tuncer@bk.tudelft.nl

[2] Department of Methodology and Statistics
Faculty of Social Sciences
Utrecht University
j.kooistra@fss.uu.nl

[3] Section of Work and Organisational Psychology
Faculty of Technology, Policy and Management
Delft University of Technology
e.akar@tbm.tudelft.nl

1. Introduction

The work described here is based on three common recognitions. Firstly, support for design communication and collaboration is at least as important as support for the actual design activities. Secondly, metadata serves as an important means to improve design communication. Thirdly, the educational context provides an excellent environment to test the effectiveness of such support. Below we describe three research projects that all focus on design communication and collaboration in an educational (and professional) context. The InfoBase project is an educational project that aims to employ ICT means to support educational processes in which (architecture) students are encouraged to learn from one another and work together, at their own initiative (Stouffs, Tunçer and Sariyildiz 2003). Primarily, it concerns the use of metadata as a means to improve the quality of design and the development of a metadata system, named KeySet, that serves to provide each design product with a unique key of keywords. The second project is a PhD research project that considers the use of a model for collections of visual design documents to support design communication in the conceptual phase of design. Specifically, it investigates a methodology for creating, managing, and collaborating on architectural knowledge structures based on a separation of meaning and organisation. The third project is also a PhD research project, which considers the social impacts of collaboration technology in the field of distributed design. Specifically, it investigates the effectiveness and efficiency of the use of collaboration technology in distributed design environments.

2. The use of metadata as a means to improve the quality of design

The development process of InfoBase, a multimedia learning environment to support group work and discourse, has been characterised by two 'revolutions' that have signified a breakthrough in the operation and acceptation of InfoBase among architecture students.

The first revolution concerns the application of the idea of '*improving quality by converting better observations out of the original observations by repetition*.' This idea has its origin in andragology (Groen 1981; De Zeeuw 1985) and poses that professional activity must be geared towards improvement or otherwise abandon its interference. Improvement only takes place when one actively enforces (claims) the desired improvement as quality of the solution. Additionally, a solution always has many dimensions and an improvement will be robust if one can lay claims *simultaneously on multiple dimensions*. In short, the better claims target multiple dimensions simultaneously, are active and rest upon previous qualities that they attempt to improve. The application of this train of thought on design provided an excellent point of departure for the organisation of the communication (we prefer: *correspondence*) system in InfoBase. Since claims are active, by definition, they acquire the form of metadata. In this way, they automatically provide the characteristics with which the design can be stored in a database (InfoBase). However, this exactly turns out to be the 'secret of the trade.' Design and metadata form the two sides of the same sheet of paper. The insight that design itself is actually the active process of assigning metadata, and therefore there are no fixed criteria concerning the assignment thereof, is only achieved in the course of the study and forms the passage to real professionalism.

The second revolution concerns the formation and introduction of the didactics with which the use of InfoBase could be made accessible (and also acceptable and appealing) and the design of the actual tool with which the metadata could be generated. The didactics and the tool (which we named KeySet) are organised in such a way that the circularity that arises in the processes of designing and assigning metadata with respect to one another, remain hidden in a first instance. Initially, assigning metadata is introduced by us as an ordinary activity: one learns to assign the 'right' keywords to one's design. The metadata tool is conceived in such a way that later in the study it becomes clear how it works: that a design relates to the already existing designs and that the point is to represent this relatedness through even 'better' keywords finds expression in metadata. Assigning keywords is a process without a beginning or an end. below, we consider these two revolutions and narrate how we learnt to perceive InfoBase in terms of a complex adaptive system and how this helped us to permit chaos and self-organisation.

System theory to the aid: complex adaptive systems

InfoBase is at the onset an ordinary database, albeit a technically advanced one. It does its work correctly but is otherwise as dead as a dodo. In order to bring it to life, we consulted both system theory (Prigogine and Stengers 1984; Zeeuw 1985) and epistemology (Saussure 1916; Foucault 1966). This led to a special observation: *knowledge is a form of information delayed under the cloak of appreciation*. Knowledge is appreciated information and comes into being through as many simplifications as are necessary to let various people understand the information. Bringing to life a collection of data is therefore also a matter of imposing (social) constraints onto the system. Bringing a database to life means to constrain the database in such a way that it becomes understandable to most users. In order to breath life into InfoBase we decided to consider InfoBase as a complex adaptive system (Kooistra, Stouffs and Tunçer 2003). InfoBase acquired the constraint that it must represent simultaneously the means and the result of social processes that are the consequence of the exchange of information among architecture students in a specific phase of their study. The complexity paradigm implies "systemic inquiry to build fuzzy, multivalent, multilevel and multidisciplinary representations of reality" (Dooley 1997). InfoBase signifies such a representation.

The starting point that every design from architecture students is considered unique, in principle, introduces chaos into the database. Every design that is submitted 'queries' InfoBase; it forces InfoBase to position the design. Since every design is unique, each design receives a position that does not coincide with any other. In this way, InfoBase ends in 'chaos,' unless a constraint is imposed that applies simultaneously with the input of data. In the case of InfoBase, this constraint is imposed with the aim that students are encouraged to learn from one another and work together, at their own initiative. This introduces the principle of order and, with it, that of simplification. The uniqueness of the designs that are positioned in InfoBase through their own metadata are placed under the constraint of human communication. "*Order arises from complexity through the process of self-organisation*," say Prigogine and Stengers (1984). The obligation that correspondence must be able to take place in InfoBase can in this respect be regarded as self-organisation. InfoBase can be considered a self-organising system exactly because the content is placed under the condition of a human concept that can be exchanged through correspondence. As regards content, InfoBase concerns an infinite (unique) collection of constructive and objective qualities: designs, facts, plans, terms and so forth (images, models, drawings, texts, etc.). As regards process, InfoBase concerns a collection of relational and subjective qualities: the students are as a group responsible for relating the contributed constructs and objects through moderation, validation and encoding of the information. It is expected from them that they express their personal opinion over these constructs and objects. In this way, the content of InfoBase changes once more and the process repeats itself.

The use of metadata

In the context of bringing InfoBase 'to life' we converted the idea of 'improving quality' into a didactic model (Kooistra, Stouffs and Tunçer 2003). This didactic model aimed at serving as a container for metadata that can be used as a design backbone. However, we did not want to pursue extensively the theoretical notions that come along with the functioning of a complex adaptive system. Therefore, we posed in a general sense that metadata derive their action from their association to data and from the relationship they maintain with this data. We said that this action consists of the fact that the metadata lays claim to the data collection to which it is associated. Furthermore, we propounded that a claim can be denoted as successful if the data collection gains quality as a result of this claim (i.e. the association of the metadata to it). We also considered that the design process manifests itself in this way; the designer lays claim to a data collection in such a way that this data collection gains quality. We provided the following simple example: a designer claims that a collection of surfaces signifies a house. This claim will succeed only if the concept of a house really occurs in this claim, that is, other designers or persons are willing to consider the collection of surfaces that has been denoted as a house to be a house. Laying claims in the form of metadata is the engine of the (design) information process (Figure 1: diagram denoting the various stages in an information process and the influence of the use of metadata on this process: information gains quality as the result of the association of metadata to this information).

Figure 1: Diagram of stages in an information process.

We further stated that the system for assigning metadata must be both robust and flexible. Robust means that the designer's claim must be recognised and acknowledged by other designers (through correspondence) (Figure 2: diagram denoting the role of correspondence in the process of associating metadata to data: metadata lay claim to data; if these claims are acknowledged, the data gains quality as a result). The system must also be flexible because, throughout time, the need for designs changes. For example, the claim to have a house designed hasn't changed throughout the centuries, however, the product of the claim has evolved with the state-of-the-art of technology, society and culture.

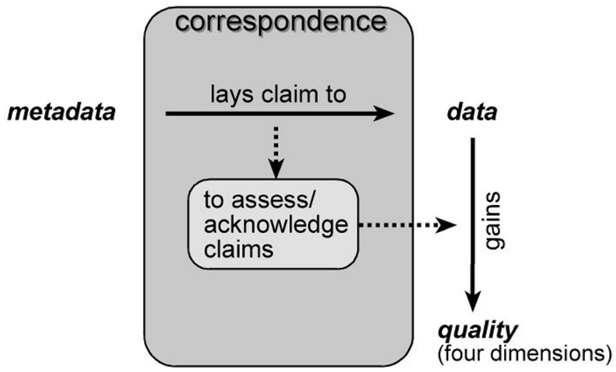

Figure 2: The role of correspondence in the process of associating metadata to data.

Applied to the context of an architectural education, we formulated the didactic model as follows: The goal is that we want the student or future architect to learn to lay claims on data collections in such a way that a vehicle arises with which this student can travel as a designer through time and space. The approach is that we teach the student to handle and use metadata along four quality dimensions (Figure 3). On the specification of these four dimensions we stated, in an abstract way, that there are constructive, relational, objective and subjective quality claims (Groen, Kersten and de Zeeuw 1980; Kooistra 2002). The constructive qualities (ideas) denote the will to make a *better* product, in the case of InfoBase, the will to improve a design. It is a form of desire that stems from the comparison with products that are already present. *This can be better!* A better idea however has no quality if others are not prepared to adopt it. This means that one needs to specify the idea in a way that convinces other (architect) designers. That introduces the objective qualities. The idea must be made concrete. There is no idea without the description of the objective, perceptible and for others repeatable elements of which the idea consists. Alas, objectively perceptible elements have no concrete meaning if they are not related to the culture within which they have to function. That introduces the relational qualities. Within a culture, a concrete design must answer the expectations, wishes and demands of producers and consumers. In their knowledge, people are joined in various economies from which one cannot escape just like that. However, there is a form of escape. This introduces the subjective qualities. People are indeed tributary in their economies but this doesn't mean that they don't have a personal emotion to it. In turn, this connects again to the constructive qualities. It is the desire for *another* (better) design that starts the process anew. Subjective quality is indeed economically the least powerful in the system; nevertheless, it forms the difference. For that reason, subjective quality stands in opposition to objective quality. It does not coincide with everything that is already there. As a result, KeySet is a metadata system of which desire forms the structure. This desire is an eternally slipping desire that stems from the way in which man has made himself understandable. Every solution to an idea means letting the idea itself behind (Kooistra 1998).

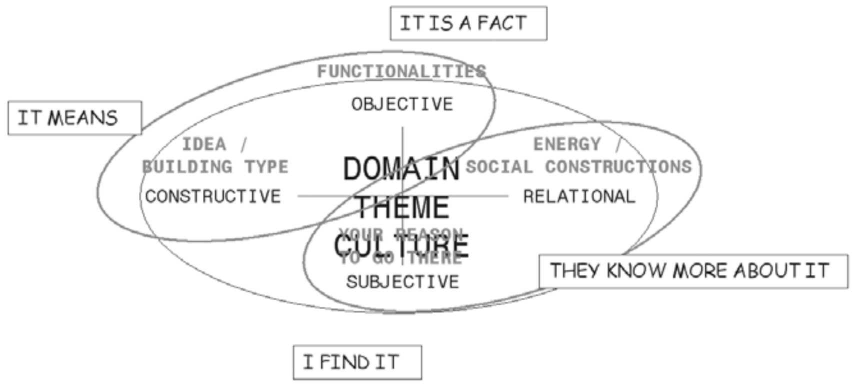

Figure 3: Diagram denoting the space formed by four dimensions of socio-cultural qualities and their interpretation for architecture.

We agreed that in the first year of the curriculum, we would be concerned mainly with the use of the model. Further on in the curriculum, the focus will turn to the handling and steering by the student himself of the vehicle that the model defines. In this way, it is as if the student goes through the process of handling an existing prefab vehicle to designing, building and handling one's own vehicle.

The use of KeySet

In September 2003, we started with an implementation of this model in the first semester of the BSc Architecture curriculum. Specifically, we introduced the students to the use of metadata when submitting course work in a computer modelling workshop (Kooistra, Stouffs and Tunçer 2004). For each image of the model they submitted they had to specify four claims corresponding to the four quality dimensions. For each dimension, a small set of keywords was provided from which the student had to choose one. A search tool provided access to the resulting collections, Figure 4: the search tool applied to the results of a first semester modelling workshop of Parc de la Villette "follies." The selected keywords are "*circular*" (constructive), "*pavilion for the purpose of recreation and relaxation*" (relational), "*front view*" (objective) and "*spatial*" (subjective).

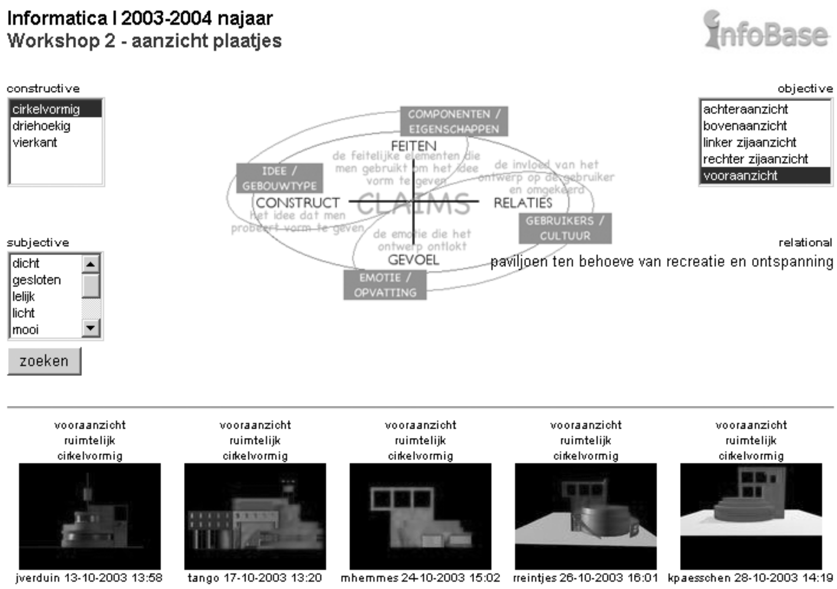

Figure 4: The search tool.

Students appreciated the formation of a cooperative database composed of their submissions, encoded using metadata and searchable accordingly. Students used the search tool to search either collection using one of the sets of claims they used to encode their own submissions. However, the introduction of the four-dimensional model proved to be too elusive and students, in general, did not achieve an understanding of the meaning and role of each dimension and the relationships between them. Important information for us came from an evaluation we performed using a questionnaire to the students, and which showed us we were on the right way. In connection with the results of this evaluation we reconceived the system for assigning metadata. The following changes are most important: We gave the system a name, "KeySet," and with this name reduced the system to a mere tool (one which the students will only distinguish to be a complex adaptive system in the course of their education). We renamed the dimensions to construct, relations, facts and emotion (Figure 5 presents a diagram of the KeySet dimensions as provided in the interface; it denotes the space formed by the four dimensions of claims and their interpretation for architecture. This diagram is presented to students as a memory aid when they lay claims on their submission) and added a help page to the system in which the tool is explained and examples are given.

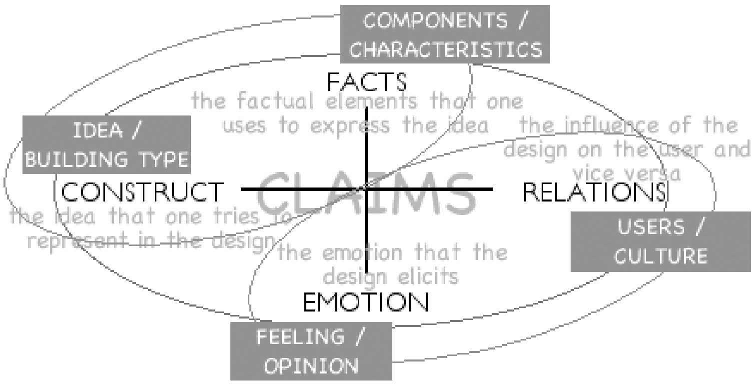

Figure 5: Space formed by four dimensions of claims.

The *construct* constitutes the idea or collection of ideas that one tries to represent in the design. The construct claims that the design best fits this idea or ideas. This corresponds to constructive qualities. Abstract examples are living, working, playing, learning, etcetera. Concrete examples are building types: house, office, workplace, theatre, school, city hall, parliament, and so forth.

The *relations* constitute the influence that the design has on the user and, vice-versa, the influence of the user on the design. Relations claim that the design fits in the social life and culture of the intended user. These correspond to relational qualities. Examples concern considerations to the use of the designed object by inhabitants, workers, visitors, students, townsmen, parliamentarians, etcetera.

The *facts* constitute the (f)actual elements that one uses to express the idea(s) (e.g., materials, techniques and forms). Facts claim that these elements give expression to the idea(s) and create a robust entity. These correspond to objective qualities. Examples concern the robust combination of materials, techniques, forms, and so forth.

The *emotion* constitutes the emotion that the design elicits from the designer or the audience. The emotion claims that the design satisfies a certain contributed value. This corresponds to subjective qualities. Examples are beautiful, ugly, functional, transparent, cold, etcetera.

By scoring a design that is placed into InfoBase with appropriate keywords on the dimensions, the (unique) code of this design comes into being with which the design is labelled. With that, justice is optimally done to the design. At the same time, a problem also arises. Since the assignment of keywords is relative – it is after all always about interpretations – care must be taken that the assigned code is also communicative. KeySet mediates technically and strategically in this. Technically, KeySet has a search programme that can retrieve all keywords and combinations of keywords that have been entered in various ways for adaptation or reuse. Strategically, KeySet is put into the (BSc) education in such a way that the student learns to handle the relativity of the system and use it to its fullest extent, without having the feeling that one is left to his or her own devices when it comes to learning to deal with the language of architectural concepts. This is achieved by setting up KeySet in the first year of the BSc curriculum in such a way that the possibility to make up one's own keywords is limited. In this case, each dimension is either completely closed (a fixed keyword) or linked to a limited menu of choices, or linked to an online architectural thesaurus with fixed architectural terms. In this way, the internal communication within the database is promoted – which is still desirable at the start of the study – while it is clear from the beginning that each design is unique and deserves to have this uniqueness honoured in a metadata system. In the second and third year, the correspondence between the designs and the management of the database is regulated primarily by the students themselves.

Last year, we started an extensive scales evaluation of the use of InfoBase and the included metadata instrument KeySet. This evaluation is carried out as part of a longer-term international research into the use of computers in learning situations The evaluation concerns the use of ICT in general and the use of KeySet as an instrument to assign metadata in particular. This research is conducted by means of two scales: the *Subjective Computer Experience Scale* (SCES) and the *Subjective E-platform Experience Scale* (SEES). These scales are designed to measure the attitude and experience with respect to computer use (SCES) and the use of ICT as work and learning environment (SEES) (Kooistra et al. 2004). SCES is an internationally validated scale. It measures subjective computer experience, which can be described as "a private psychological state reflecting the thoughts and feelings a person ascribes to some existing computer event" (Smith Caputi and Rawstorne 2000). SEES is a scale that we designed and tested ourselves in previous research. It measures the subjective assessment of experiences with ICT applications in education (the KeySet section of the scale measures the subjective assessment of experiences with KeySet applications in education). The measuring was repeated before and after a second semester computer modelling workshop. The correlations found between the SEES ICT and KeySet factors and the variance analysis conducted has clarified the strategy that we think that needs to be followed (Kooistra et al. 2005). Make students more familiar with dealing with metadata (KeySet) and they will find it worthwhile and also rather fun. The latter not only depends on whether the instrument is profiled appropriately but also on the courses or workshops in which it is included.

Conclusions

InfoBase is a technically advanced database. In comparison to previous versions, satisfaction about the technology has also strongly increased. The addition of the KeySet instrument to InfoBase gives the database extra dimensions. It makes InfoBase into both a didactic and strategic instrument. Didactically, InfoBase with KeySet is well equipped to teach students what it means to share information, to handle metadata and to understand chaos and order in their combination as essential factor for the information content in a database. Strategically, InfoBase presents a very interesting link between education and profession. The fact that students learn to share information in a professional way during their education, enables them to continue this (academic) attitude in the architectural discourse upon graduation as a professional (alumnus).

Using the idea of a complex adaptive system has greatly helped us to analyse the force field that is present in a cooperative database. We were able to take a more open position with respect to allowing chaos to enter the system, knowing that this identifies the uniqueness of the submissions. However, because we do not equate the permission of chaos to the preaching of it and, in the context of educational, we also have an obligation to teach the students how the field of tension between chaos and order behaves, we have introduced a few constraints that can be considered as the simulation of the actual idea of self-organisation. These constraints concern both the requirement of communicability and a description of the dimensions according to which the metadata must be generated for a design. We emphasise that the assignment of metadata is always chaotic (everyone understands differently and provides different explanations) and that this only changes when one unleashes the constraint (delay) of communication/correspondence and self-organisation takes place in the form of the adaptation of the keywords to one another. We propound that the final lesson is that establishing relations, even though it yields appreciated knowledge, at the same time costs information (uniqueness disappears).

3. Information modelling in architecture

The main question of this research is: How can we support design communication in the conceptual phase of design using a model for collections of visual design documents?

Architectural design is a complex process that involves a large amount of information with numerous dependencies. This information is commonly represented and communicated in a collection of design documents of various formats. Many document management applications exist that are also used in architecture, but these are not suitable for the early, conceptual stages of architectural design.

Needed is a visual, flexible and extensible environment that supports creativity and that enables the collected information to be reused in further projects. Flexibility is necessary in inputting and retrieving the information. When using such an environment, and especially in the early stages of design, one is not necessarily interested in a specific document, but in search of a collection of information related to a concept of interest, or one may be just browsing through images to get new ideas - creative coincidences. The document structure and the organisational structure must be extensible in order to be able to reuse the information.

A unified representational framework is necessary for such an application (Tunçer, Stouffs and Sariyildiz 2002). We have developed a methodology that entails the separation of meaning and organisation. Meaning, or semantics, is structured as a flexible and extensible semantic network of concepts and relationships that acts as a backbone for knowledge organisation. This network can be defined by a user or a group, can be project or institution specific, and defines a common language among users. This definition of a network has been integrated into the InfoBase system. The organisation, or the documents, can be divided into smaller components. Each item is associated with one or more concepts from the semantic network. The methodology offers a flexible and extensible framework and a rigorous recipe to create, manage, and collaborate on architectural knowledge structures. An environment that implements this methodology offers a flexible and extensible framework for creating and managing architectural knowledge structures.

The use of such a system in education and practice also entails process and organisational issues concerning the users and their organisation. The use of the system must be embedded in the organisation and supported by the managers/educators of the organisation. The highest threshold for the actual use has been found to be the initial acceptance of such a system. Users generally find the system and its functionality useful and innovative, but if it does not produce visible benefit to their work, or impedes too much on their daily work routine, they tend to abandon the use. Therefore, the user interaction and interface design must also incorporate the specific process of the design task and culture of the organisation. This makes it necessary for the process knowledge to be incorporated in the design of the software from the very early stages on. If the embedding into the organisation is not complete, the actual success of the system will also be limited.

Four case studies in architectural education and practice have been implemented using the results of this research, using the InfoBase structure and scripts (Figure 6). The first one is the Analysis Presentation Tool - 3 Ottoman Mosques. This is a web-based environment implemented using XML technologies that serves to model, present, search and browse extensible and semantically rich precedent libraries. This was implemented as a test case. The second case study is the Design Analysis Network (DAN). DAN is a web-based educational environment that aids precedent-based analysis of design projects. The result is an extensible and semantically rich precedent library. This was used in the 2nd year design studio of our education. The third case study is the Blob Inventory Project (BLIP). BLIP is an integrated web-based environment that serves to model and retrieve conceptual early phase design processes of free-form buildings and serves as a design aid. This was used in a masters course in our education. The final case study is the Design Map. Design Map is a web-based knowledge management environment being used in a real life professional project by a project team in the architectural office MECANOO.

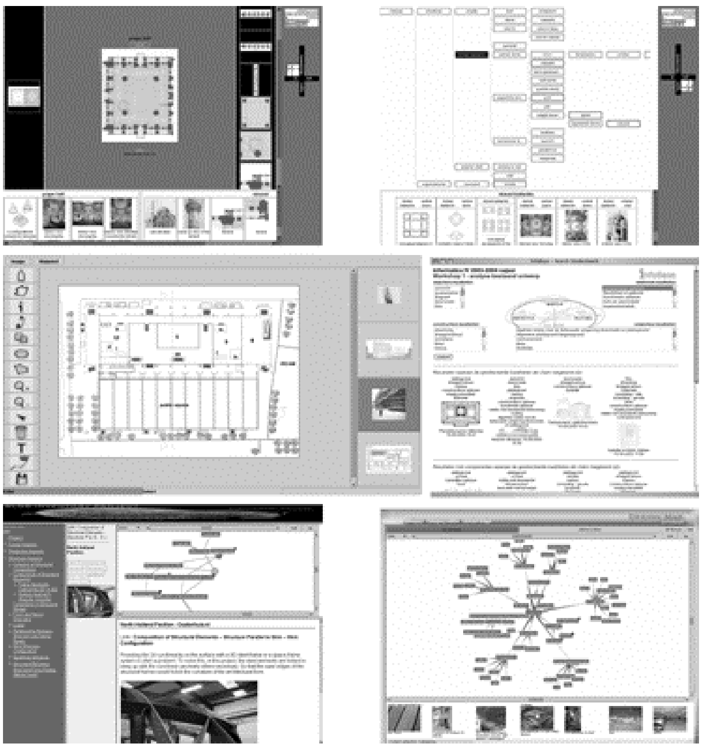

Figure 6: Four case studies in architectural education and practice.

4. Collaboration technology in distributed design

The main question of this research is: How can we increase the effectiveness and efficiency of collaboration technology use in distributed design environments? Collaboration technology is closely related to the terms CSCW (Computer Supported Cooperative work) and Groupware (Munkvold 2003). CSCW originated during a workshop at Digital in 1984, where a group of researchers focused how IT (Information Technology) could support collaboration (Grudin and Poltrock 1997). One of the earliest works applying the term Groupware is the book Groupware: Computer Support for Business Teams edited by Johansen (1988, cited in Munkvold 2003). There suggestions are presented how to apply collaboration technology for supporting team collaboration. Later, the application has broadened from originally supporting workgroup or team level to organisation wide applications such as document management and knowledge management systems. Therefore, the term collaboration technology better represents this wider focus and the term groupware has gradually faded (*Ibid*). However, in the literature it is still possible to see the use of these three terms, synonymously. In this research the term collaboration technology implies computer support for collaboration at group level and organisation level.

Collaboration technologies are changing the world of work. The consequences of these technologies in work environments have been a research issue for a decade or more and have attracted researchers from academy and practice. Although early discussions about the impact of these technologies were technology oriented, with the recognition of their social impact on work environments, the social dimension is also added to these discussions. The focus of this research is on social impacts of collaboration technologies in the field of distributed design. Design is collaborative by its nature. Therefore, collaboration technologies can bring a lot of opportunities to improve the collaboration during the design process. However, despite the robustness of technologies being developed, effective use of collaboration technologies has not yet been a part of the daily routine of designers. The aim of this research is to identify the sort of enablers and disablers that facilitate the effective use of collaboration technologies. Some examples of these enablers and disablers are the attitude of the designer towards technology, the culture of the organisation where the technology is implemented, and the extra work load that is required from the designer for the effective use of the technology.

In order to answer the main question following key questions are asked:

- What is the current state of collaboration technology use in distributed design environments; what types of collaboration technology are used; what are their functionalities?
- What sorts of problems are encountered in the course of collaboration technology use?
- What sorts of team characteristics affect the use of collaboration technology in design environments?
- What is the influence of current organisational structures on the implementation and use of collaboration technology; what sorts of strategies are developed for their effective use?

So far, this research is conducted both in an educational and a professional context. The research results that emerged in the educational context have identified the major items concerning the use of collaboration technology on the team level and the broader institutional aspects (Akar et al. 2003; Akar et al. 2004). Together with these items, a literature review and the interviews conducted in certain international design companies have revealed major dimensions which could be effectual on the collaboration technology use in distributed design environments. In the final stage of the research a prescriptive framework will be developed for the effective and efficient use of collaboration technology in distributed design environments.