Facilitating Architectural Communities of Practice

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Abstract. An architectural community of practice is formed by designers working together on a common goal. Members of this community share a common professional language where the vocabulary of this language represents a shared understanding. Members of a community of practice operate both by recording common knowledge into documents and by actively participating in social processes in order to personally contextualize this recorded knowledge. ArcIMap is a framework, consisting of a method and a computational model, that facilitates communities of practice to acquire, represent, share and reuse design information and knowledge, and targets the creation of situated digital environments where teams of designers communicate and collaborate using this information and knowledge. This paper describes ArcIMap, its background, and one of its implementations for a community of practice working on an urban renewal project in an educational context.

Keywords. Community of practice; correspondence; complex information structure; information modeling; urban design.

Communities of practice

Designers communicate using countless analogies and metaphors, in the form of narratives and stories, and during such design conversations, use words and drawings (pictures, diagrams) to convey the embedded knowledge in these conversations. In order to understand the numerous references in design conversations, one needs to possess certain (domain) knowledge and a common understanding of a vocabulary shared by the (professional) group, i.e., the design community. Hence, groups of design professionals share a common language (Lawson, 2005; Lloyd, 2000). This common language also contains vocabulary derived from the common use of analogy and metaphor.

The vocabulary of this common language refers to knowledge shared by the members of the group. Since designers reuse their own designs and design experiences, an environment that stores and organizes design information and knowledge should also support the recording, forming and maintenance of common knowledge among its users in order to support novice designers to connect common vocabulary to schemata that can be understood within the community. The members of the community, designers, students and professionals learn from and with each other (Schön, 1985), through reviews and critics, but also through direct communication and correspondence on each other’s work (Stouffs et al., 2004). Such a community within the context of architectural designers – practitioners or students – can
be called a community of practice.

“Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (Wenger, 1998). People who learn collectively in a shared domain form communities of practice (Bowker and Star, 1999). Learning in a community of practice is not limited to novices, everyone in the community learns. Communities of practice have existed as long as humans have learned together, and humans belong to numerous communities of practice throughout their entire lives. The combination and parallel development of three important elements cultivates a community of practice (Wenger, 1998):

- Members share a domain of interest and are committed to the domain, and therefore possess a shared competence that distinguishes them from other people.
- Members interact and engage in joint activities and discussions in order to learn from each other and share information within their domain.
- Members are practitioners who develop a shared repertoire of resources: experiences, stories, tools, and ways of addressing recurring problems – in short a shared practice. This takes time and sustained interaction.

Communities of practice perform, among others, activities for problem solving, information and experience sharing and using, and documenting and mapping knowledge. Members of communities of practice operate in terms of generating and handling common knowledge both by recording knowledge into documents in order to support cooperation and mutual understanding of informal group activities among members, and by getting actively involved in social processes in order to personally contextualize this recorded knowledge. It is the combination of these two activities that enables knowledge handling within communities of practice. In this process of knowledge handling, explicit and tacit knowledge and formal and informal processes are not separated. Wenger (1998) calls this process in its entirety “reification” and “participation”, Kooistra and Hopstaken (2002) call it “ice-canoe”.

Creating a digital system for acquiring and managing knowledge collectively as a community of practice has many advantages (Wenger, 1998). Firstly, members take collective responsibility for managing the knowledge they need, recognizing that, given the proper structure, they are in the best position to do this. Secondly, communities among practitioners create a direct link between learning and performance, because the same people participate in communities of practice as in design teams. Thirdly, members can address the tacit and dynamic aspects of knowledge creation and sharing, as well as the more explicit aspects.

**Information processes for communities of practice**

In the context of an electronic environment that enables the acquisition, use, and reuse of knowledge where the knowledge is built up and used by members of a community of practice, tools and mechanisms for meaningful transactions and correspondence among members are needed in order to create a useful and usable environment.

Correspondence is communication with the aim of reaching an agreement. A digital environment possessing the qualities described above can play a role in this, offering designers access to a broader selection of work and offering additional means for communication and correspondence. As design practice increasingly becomes distributed and multi-disciplinary, “in a design practice [design] knowledge has to become common or shared for the team to operate effectively” (Lawson, 2004: 453).

A system where a design team can simultaneously and collaboratively model their cognitive design models is important as a design aid, but it is also important as a means to record design knowledge and experiences for future generations.

Such an environment relies on the specification of an information process that defines the activities
related to information and knowledge on a general level. The adopted information process (Stouffs et al., 2004) considers four main groups of information activities in a cyclic process: searching and generating, communicating and storing, distributing and exchanging, and validating and discarding information and knowledge. The goal is to achieve a system that acts as a “deputy: a partly virtual and partly human substitute that has the (managing) power to deal with collected information, to make conclusions, to take initiatives” (Kooistra and Hopstaken, 2002). This ‘deputy’ can be a rigid one, where the information or knowledge that is stored in the system is fixed. This is a closed system. A discourse of humans, mediated and directed by the system components, is an open system. Open systems are systems in a state, far from equilibrium, that show no tendency towards an increase in disorder (Popper, 1982). This structural disorder in the system is ensured by the nature of the open system when it is considered in terms of a dynamic set of interacting entities where no single individual or organization is in control of the construction or, consequently, behavior of the set as a whole (Frederiksson and Gustavsson, 2001). An open system is needed in order to ensure reification and participation in a community of practice, because a community of practice is non-hierarchical and dynamic, and its interactions are not predefined.

We can consider such an open system as a complex adaptive system. According to Dooley (1997), “a complex adaptive system behaves/evolves according to two key principles: order is emergent as opposed to predetermined, and the state of the system is irreversible and often unpredictable.” Examples of complex adaptive systems include social insect colonies, the brain, traffic jams, national economies and stock markets, industrial infrastructures, and any human social group-based endeavor in a cultural and social system such as communities of practice (Yang and Shan, 2008). Emergence and self organization are important for the formation of complex adaptive systems.

Complex information structures

When the content of an information system is both means and result of social processes of a community of practice, in the form of correspondence, it can be said to support a complex adaptive system. In order to do so, it must be both robust and flexible (Stouffs et al., 2004). Robustness in this context means that the system must offer mechanisms, that don’t change over time, for the participants to be able to correspond on the content. Flexibility in this context is allowing the content to change and reflect (on) the changes and evolutions that come with the state-of-the-art of technology, society and culture.

Correspondence was described earlier as communication with the purpose of achieving agreement. In the context of an information system, the agreement is on the value of information. Through correspondence, information gets value. If users agree on the value of a piece of information, it is validated and can be kept. Correspondence on design information and knowledge is a necessary characteristic of an open system.

In the process of document organization, the issue of the value of the document, and therefore the value of information contained in the document, is a critical factor in deciding both to keep the document, and also how it should be placed within an organization scheme. A document has value if it is of actual or potential use to someone. The most important factor in determining the value of information is figuring out how much and why it is important. Through correspondence, this is done collectively by the users of the system. The process of correspondence is achieved when a user creates a document in the system and makes a number of claims about it. Other users may agree with these claims, either explicitly, or simply by using or reusing this document. If the document is unused or the claims not agreed upon, the document becomes redundant and obsolete in time. The value of a piece of information is a qualitative judgment, not a quantitative one, and the value is not static; it changes over time.
We aim at building digital environments for the acquisition, use, and reuse of information and knowledge where the knowledge is built up and used by members of a community of practice. Such environments contain collections of design documents, and an organizational structure that is built up by the users of the environment, giving the users the possibility to reflect on the knowledge entities and their relationships. Such structures are considered to be complex information structures.

Definitions of complexity are often related to a system. According to Simon (1962), a complex system is one made up of a large number of parts that interact in a nonsimple way. A complex information structure is a result of activities performed within a complex adaptive system, especially around information organization. Information structures are created, at a minimum, by a collection of information entities, in this case, documents, an organization of these entities, and a specification of the relationships between these entities. The information intensity involved in the structure raises questions of complexity: how to organize and intra-relate large amounts of information in order to facilitate correspondence on this information. This involves issues of both modeling and visualizing this complexity.

The best way to handle the complexity of design information is not through a simplification of the information structure. On the contrary, a complex information structure that enables views unbounded by the original documents is advocated. Complexity is a necessary characteristic of information models if they are intended to yield more than a few predefined viewpoints to the information. Targeting a largely unfamiliar audience, the indeterminacy of viewpoints provides the possibility to anticipate individual requests from the audience. Unexpected viewpoints derived from the information can also invoke new interpretations of existing information, which in turn can lead to creative discoveries. An important question is how to achieve such complexity in a simple approach. We adopt a representational language as a common syntax for describing the organizational structure, the documents, and their integration in a global information structure where there is an integrated structure of components and relationships, represented in a uniform way. A computational framework that supports this structure needs to fulfill some requirements about the representation of the documents, the recognition of structures and relationships, and the formal structure of the resulting model.

The complexity of the information structure, however, should not stand in the way of its ease of use, especially when integrating individual documents into it. Therefore, the tools, mechanisms, and techniques for creating the integrated information structure should be as clear, straightforward, and intuitive to use as possible. These tools, mechanisms, and techniques must not change over time for the participants to be able to correspond on the content. The content, on the other hand, changes, reflecting on the changes and evolutions that come with the state-of-the-art of society and culture.

Architectural Information Map – ArclMap

We have developed a framework for communities of architectural practice to correspond on complex information structures. Architectural Information Map (ArclMap) is a framework consisting of a computational model and a method for information organization and knowledge modeling in the conceptual phase of architectural design (Tunçer, 2009). Groups of designers who wish to store, organize, share, reason on and reuse collections of (visual) design information should use ArclMap in order sustain their community of practice. This framework defines an open system in order to ensure reification (recording of common knowledge into documents) and participation in a community of practice. ArclMap defines a way to work with information collections without prescribing a fixed design vocabulary or classification structure. Users of an application of ArclMap are also the creators of an information structure that resides in the application.
The goal of ArcIMap is to define a framework for the design and creation of digital applications that support designers in the conceptual phase of design, for example, by creating extensible libraries of design documents, and recording knowledge structures of designers. This framework can be used both in educational and professional contexts, although the process and requirements will differ. The final goal of the ArcIMap framework is to derive at specific implementations in specific contexts serving specific architectural communities of practice, yet from general principles. It is not the intention to develop a global system that can deal with all documents belonging to all kinds of building projects, but to achieve an integrated information structure of components, relationships and metadata from a collection of design documents and the knowledge that resides in these documents. The framework can then be implemented for different purposes, domains, contexts, or architectural bodies.

An application of ArcIMap must be rooted in its use context, therefore, a study of the social and work processes of the users and the organizational structure of the context in which it will be used must be studied in the design stage of the application. Therefore a participatory process is needed in the software and interaction design of the intended application. This requires a study of the users, their professional context, and a study of work and interaction processes in the form of interviews, observations and discussions within the use context of the application, and a translation of these into software requirements. Before embedding the application in its use context the users of the application must also be enlightened about the application, its purposes, and the goals and premises of the underlying model. Additionally, its users must receive instruction on the concepts behind ArcIMap before using the system.

Figure 1 presents the ArcMap computational model. ArcMap defines a semantic structure and a document structure. A semantic structure made up of a network of concepts and semantic relationships acts as a backbone for the organization of knowledge and information. Some examples of semantic relationships are is-a, has-a, which are hierarchical in nature, or freely defined associative relationships, such as 'reminds me of'. Being able to freely define associative relations between concepts semantic relationships allows users to record personal associations in their knowledge structures, enabling the recording of internalized procedural knowledge, and possibly even tacit knowledge. The semantic structure is conceptually derived from concept maps (Novak, 1998), is representationally a semantic network (Sowa, 1991) and additionally uses aspects from conceptual graphs (Sowa, 1984) and XML topic maps (Pepper and Moore, 2001). The concepts and conceptual relationships in the semantic structure are typed, respectively through the concept type hierarchy and the relationship type hierarchy. Conceptual relationships can be minimally typed according to a set of predefined (but extensible) semantic relationships.
relationships in order to support information retrieval. When relationships are not typed, the danger looms that every relationship is unique, and retrieval result sets may be quite limited. Another advantage of typing the relationships is to make users consider the nature of the relationships they create. This will have a positive effect on the cognitive processes of users.

Beside the semantic structure, a collection of multi-media design documents that are collected and produced during the conceptual design phase constitutes the document structure. Documents are interpreted and broken up into components, and these components within and between documents are related, and these relationships added to the representation. Document decomposition enables metadata to describe the parts of documents where they are most relevant, such that those parts of documents can be reached directly while searching or browsing. Elements of the semantic structure (concepts, conceptual relationships) describe these documents or parts thereof through association. This allows and supports associative browsing, where users browse using the underlying associative relationships between information entities. This cognitive mode of browsing enables cognitive jumps and unexpected creative discoveries. The documents in the document structure are named components in the model. Occurrences relate components to members in the semantic structure. Occurrences are typed.

**An ArcIMap application for intelligent urban design**

At the beginning of a design project, design teams usually gather and collect relevant information in order to familiarize themselves with the project context, and to set the problem framework and define the design issues in which they will operate. This information is (implicitly or explicitly) organized around a number of aspects. The designer(s) already has notions and ideas on these design aspects even before the information collection activity. However, the collected information definitely provides cognitive support for problem setting. The cognitive framework of the design problems, entities and relationships forms partially during the information gathering and organization process. The aspects that are used to organize the collected information can demonstrate this cognitive framework if represented in a suitable manner.

We have developed such a cognitive framework as part of a collective information gathering and brainstorming activity within the context of an educational experiment in the form of an M.Sc. elective course that implements a design aid for urban designers in order to make informed design decisions. ArcIMap served as a model and method for students in the first stage of this experiment.

For this educational experiment, we followed a methodology that involves the collective creation of a knowledge model, and the use of this knowledge model for making informed design decisions in the final design. In a number of exercises, the students studied an urban design situation by collecting and processing information for a knowledge model, and by applying this model. The case study for the course was an urban design transformation of the Wijnhaven area in Rotterdam. It is a triangular island at the edge of the Rotterdam city centre and close to the river Meuse. At the time the course was conducted, new development on the island had just started. In the meantime many high-rise buildings have been built there.

The island, in its previous form, primarily consisted of postwar office blocks, with an average height of 5–8 floors, dating from the 1950’s. These formed a usable, but unattractive urban design fabric. At the end of the 1980’s, the quality of the area started to decay as a number of office buildings became obsolete, which led to a rise in vacancies (Christiaanse and van den Born, 2002). The Municipality of Rotterdam has created a plan to enhance the area’s residential use, and is currently putting the plan into action. Within the Rotterdam Center Development Plan, it is a part of the Waterfront area, which is planned mostly as a
residential area. The plan of the city is to build 3750 residential units in downtown Rotterdam by 2011. The maximum height limit for the area is 150 meters. The Wijnhaven island is one of the most expensive locations in a downtown area for residences and offices in the Netherlands, both in terms of selling prices and rents.

In the first workshop of the course (that lasted a full day), the students got familiar with the site and the related considerations in order to define a project description and program brief themselves. The students collected relevant information from the current situation, and collectively shared and managed this information using an application of ArcIMap (Akar et al., 2004). ArcIMap offered them a method and digital environment.

In the first part of the workshop, students concentrated on the information gathering activity. They analyzed and investigated the site and the surroundings. Some issues students concentrated on were urban aspects, accessibility, functionality, views and daylight issues. Students first collected information about the site in the form of plans, photographs, websites and articles. At the beginning of the second part of the workshop, all students and the instructor conducted a brainstorming session. The goal of this session was to define a collective framework describing the important aspects that play a role in the preliminary design stage for this specific site, and the relationships between these aspects. This session started by each student presenting the gathered information, and a short interactive discussion. Then, the whole group participated in a discussion of defining and relating design and analysis aspects for problem setting. These aspects were noted on a large paper, one of the students volunteered to be the mediator and recorder of this process. Next, another round was made, this time each student named a number of necessary aspects that needed to be taken into account, and these were discussed and recorded. At the end of several rounds, all relevant aspects had been collected. Then, students collectively defined the relationships between the aspects. First, a tree structure emerged. Then, students started defining more associations between various branches of the tree. This defined the final visual structure of concepts and relationships defined as a concept map. The students stated that some of these aspects and relationships came up from their previous knowledge as designers, and some they learned by searching for and collecting information. In any case, the resulting structure represented their collective cognitive framework for problem setting for a design for a specific site. The students then translated this map to the digital environment and refined it collectively over time, adopting it as the organizational backbone of the collected information and generated knowledge, and relied on this collection during the rest of the design process. Figure 2 presents the complex information structure as the result of the activities of the students using ArcIMap.

In the later practical work sessions of the course, students worked with a list of aspects, which are mainly based on the Birmingham planning policy framework for tall buildings [1]. These aspects, grouped under the headings context, program criteria, impact on surroundings, architectural design, and on site accessibility, were collected in a data collection form. The students went to the site, read articles and did research about the site in relation to these aspects, and each student filled out at least 6 data collection forms. Each aspect in the form was marked by selecting one of 5 slots, ranging from ‘strongly agree’ to ‘strongly disagree’ as a reaction to the statement made. These marks were later normalized to a value between 0 and 1 and all the values from all the sheets were merged together to form a data matrix to train the knowledge model. These also served as the variables in the knowledge model. The knowledge model used computational intelligence techniques such as fuzzy logic, neural networks and genetic algorithms. Once the knowledge model was established, the design exercise aimed to obtain a certain design guide providing a quality of life, which is desirably high. This definition of quality of life was left up to each student, and achieved by creating a
weighted combination of selected aspects. In order to fulfill these constraints, the selected aspects were taken to be at the output of the knowledge model where the rest of the variables were at the input. Having established the knowledge model as such, the pattern of the input variables, which yields the satisfaction of the quality of life criterion, was searched by means of a genetic algorithm. The definition of quality of life acted as the fitness function of the genetic algorithm. The knowledge model
was presented to the students as an easy to use application. The use of the knowledge model clarified
the relations between different aspects and allowed
the user to infer urban design principles from it. The
students used these relations and principles in their
own design for the area, up to the level of massing
studies, and for the specification of functional enti-
ties. More information about this educational experi-
ment can be found in Tunçer et al. (2005).

ArcIMap has the potential to be implemented in
many more projects for the creation of Future Cities
by communities of practice. However, consideration
for context and implementation is needed.

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