
Learning in Context: Contextual Libraries in Architecture Distance Education^{1[1]}

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Abstract

This paper introduces the notion of context in the architectural learning process. Designing and learning are social processes in which knowledge is learned in applied situations. A WEB-based application, called "Architectural Contextual Library", is presented as a means to arrive to a collaborative learning environment in architecture projects. The paper discuss the types of knowledge involved in architectural design, the difficulties in formalizing and sharing knowledge, and the implementation of a visual argumentation process through a design example – the design of stairs in a typical house.

Resumo

Este trabalho discute a questão do ensino/aprendizagem do projeto de arquitetura através da aplicação da noção de contexto na explicitação do raciocínio projetual. Uma aplicação baseada na WEB, denominada "Biblioteca Contextual de Arquitetura", é apresentada como auxílio à aprendizagem colaborativa do projeto arquitetônico em ateliers. O artigo discute os tipos de conhecimentos envolvidos no projeto de arquitetura, as dificuldades de formalização e compartilhamento desses conhecimentos, e a implementação de um processo de argumentação visual através de um exemplo do projeto de uma escada.

Palavras chave

aprendizagem colaborativa, ambientes interativos de aprendizagem, raciocínio contextualizado

Key words

collaborative learning, interactive learning environments, contextual reasoning

1. Introduction

Design is a complex activity. Problems faced by architects and engineers are ill-structured and incomplete. It is also a knowledge-based process in which information and knowledge are processed simultaneously by a team of architects and engineers involved in the life phases of a product. Design practice encompasses a series of creative activities such as artifact planning, product development, product synthesis and problem solving. Design also involves an incremental learning process as part constituent of designers' activities.

Design is also seen as something with a great deal of innovation, but this is not the current practice in companies. Many projects have a high innovative content, but most of new projects follow another pattern, where innovation is not high. The classes of design most commonly found are adaptative design and variant design, which involve the use of known strategies, or established design plans to arrive to new solutions. In these cases, the problem decomposition strategy is already known and some classes of solution are already identified. In other words, the initial perception of the product structure is known and the disciplines needed to solve the design problems

^{1[1]} Este trabalho contou com o apoio da CAPES, processo BEX 0857/00-9.

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are already identified, as, for example, the case of designing a townhouse for a medium class family. Despite this, there is always some particularity in the design of a product, so knowledge is always required in the design activity. The product is a unique object and one translates elements that make the product unique as design constraints. The constraints are the element that encompass contextual knowledge on the product.

Learning and designing are closely related activities where finding a new solution involves the reuse of knowledge abstracted from previous projects, i.e., involves the building an interpretative context of the former design situations to make them ready for use in a current task. At the initial steps of design progression, a way to understand and to structure a design problem is to retrieve former design cases and design plans to form an abstract knowledge that can be further explored. It is an inductive learning process that includes assimilation of new knowledge in a body of known and organized knowledge for future use. The information gathered in former projects is reshaped and reorganized, allowing engineers and architects to generalize and abstract ideas that are explicit in particular situations to use them in analogous situations.

It is also important to stress that both learning and designing are social processes, as underlined by the literature on community of practice (Brown & Duguid, 1991; Wenger, 1998) and on design science (Bucciarelli, 1994; Naveiro, 2001). In this way, design is considered much more effective communication and collaboration, an environment for negotiation and decision.

Designing a product or a building involves the perception of the artifact structure that dynamically changes along the design progression, and the translation of each instantiation into the generation of new ideas. The artifact attributes captured by participants, and their interrelations within the whole, permits to clarify the organization of design tasks accordingly with the design state and with the participant's role. The way participants capture artifact attributes is also context-dependent, as each one must build an interpretative context of the artifact capable to link their universe of specialization with the collective common goal.

We start by reviewing in section 2 some ideas and characteristics of knowledge and context as for to design activities. In section 3 the topic of learning in collaboration is explored and focused in the practice of architecture teaching. In section 4 the notion of contextual libraries is developed, the Architectural Contextual Library presented, and an example of a stairways's design application is described.

2. Context and knowledge

Researchers in computer science, mainly belonging to the Artificial Intelligence (AI) community generally try to define knowledge by a progressive process of construction going back to data. Data is defined as the symbols perceived by a person transformed to information by the interpretation of what is perceived. In this way, information is data with meaning. Thus, information is structured data with a semantic content expressible by natural language. It is then data with a meaning visible or understandable, something shareable and immediately usable by human beings based on their knowledge.

As stressed by Brezillon and Pomerol (2001), information is the output of data interpretation and the input to a knowledge-based process of decision making that leads to knowledge accumulation. The authors argue that knowledge is information incorporated in an agent's reasoning and made ready either for active use within a decision process or for action. It is the output of a learning process that makes information something ready to use within a decision-making process. Thus the role played by knowledge is to transform data into information, derive new information from existing ones and get new knowledge. As it can be observed, knowledge plays two roles in this process, being simultaneously a means to transform data and a result of the

transformation process.

Defining a knowledge structure for a design problem and its solutions is a knowledge-based learning process that involves practical knowledge and theoretical assets as well. The distinction between theory and practice is commonplace in many domains close to cognitive science. In the AI community, the previous distinction is intertwined with the discussion about deep and surface knowledge (see, e.g., Steels, 1990).

It is commonly admitted in AI that deep knowledge refers to domain models and causal explanations that go back to nature laws, whereas the surface knowledge is represented by practical rules that can be acquired from people doing efficiently a given task (human experts). Thus, we see that, on the one hand, the deep knowledge is very similar to know that. On the other hand, it is not so clear that surface knowledge is equivalent to know how.

The discussion deep versus surface knowledge is contemporary to the distinction between procedural and declarative knowledge, which was introduced in artificial intelligence by McCarthy and Hayes (1969). Roughly speaking the procedural knowledge is a knowledge expressed in expert systems by rules or, in organizational life, by procedures. Declarative knowledge refers to more descriptive knowledge represented by objects, or agents in new programming languages.

The notion of "practicability" offers another possible way of analysis. This has been renewed by the study of "communities of practice" (see Brown and Duguid, 1991, 2000) and Wenger (1998). This notion of practical knowledge is particularly relevant in learning because it has been observed for centuries that some knowledge needs apprenticeship (i.e., practice) to be learnt whereas another does not require such practice. This discussion is not far from the previous one in the sense that deep knowledge is probably something that can be got without practice, but surface knowledge cannot be assimilated without practice (Clancey, 1995).

In apprenticeship the contextual information is acquired by doing. Actually, mastery in a job may partly result from some rules that are given by masters, but practice or knowing how cannot be reduced to rules; this is just the first reason apprenticeship is necessary. This last problem is recurrent in knowledge engineering. Moreover, the lack of contextual information about the task at hand has been recognized as a weakness of describing a complex task as a set of rules.

The question of the practical knowledge nature opens another discussion about tacitness versus explicitness. This discussion has been recently enlightened by Nonaka (1994) who distinguishes explicit and implicit knowledge and four movements related to them.

Explicit knowledge is easily shared whereas implicit knowledge is highly personal. This last type of knowledge is not articulated and is mixed with emotions (Damasio, 1994); it is the result of some internal processing (Polanyi, 1962). In decision making, this is reminiscent to Klein's Recognition-Primed Decision (1993). The discussion about tacit versus explicit knowledge is not far from knowing how versus knowing that while it stresses the appropriation components. The tacit knowledge implicitly belongs to somebody whereas explicit knowledge can be shared and is generally public.

We would also distinguish between tacit knowledge that can be made explicit and tacit knowledge that cannot be made explicit, even if this later can be shared in a community of practice. This is the case of many handling skills in many craft jobs, and is also the case in teaching architecture by assigning projects to the students.

The distinction between tacit and explicit is also important whereas we believe

that any kind of knowledge can be made explicit or implicit depending on the circumstances, the persons and the society. As stressed before, learning and designing are both social processes where “know how” acquisition and “know how” validation are two central issues.

Another important issue related to knowledge and to learning processes is context. From an engineering point of view, context can be seen as the collection of relevant conditions and surroundings influence that make a situation unique and comprehensible (Anderson, 1995). A person doing a task normally identifies which knowledge is relevant to do his job in his repertoire, i.e., the set of pieces of knowledge accumulated along his working life. Accordingly with Brézillon and Pomerol (1999) this chunk of knowledge judged important to a specific step of task performing is called contextual knowledge.

The authors also argue that, within a decision making process, a part of the contextual knowledge is invoked and situated according to a given focus, thus reducing the universe of search. This part is named the proceduralized context associated with the decision process.

The relationship between these ideas and a classroom situation is very close. When a design task is assigned to a student, his perception of the contextual knowledge is not straightforward, i.e., grabbing relevant knowledge from his repertoire is not easy for a novice. Design tasks are normally ill-defined and incomplete, so, to the student fulfil the requirements implicit in the task, he will need help to turn explicit the contextual knowledge associated to the proposed situation. The lack of information found in all engineering projects is fulfilled by a human-human cooperative debate established between the student and the teacher and among students.

An important issue is the passage from contextual knowledge to the proceduralized context. This proceduralization results from the focus on a task. Thus, it is task-oriented just as knowing how; it is often triggered by an event or primed by the recognition of a pattern.

Another aspect of proceduralization is that people transform contextual knowledge into some functional knowledge or causal and consequential reasoning to anticipate the result of their own action. This functionalization, or proceduralization, obeys to the necessity of having a consistent explicative framework to anticipate the results of a decision or an action. This consistency is obtained by reasoning about causes and consequences in a given situation.

A second proceduralization aspect is a kind of instantiation. This means that the contextual knowledge or background context needs some further specifications for perfectly fitting to the task at hand. This precision and specialization brought to the contextual knowledge is also a part of the proceduralization process. Both processes are experienced by architects when designing and representing their instantiations' through graphical representations of their ideas.

3. Learning in collaboration

It is already stressed that learning and designing are social processes (Wenger, 1998 & Naveiro and Oliveira, 2001) and interactions among peers around appropriate tasks can increase the mastery of critical conceptions. There are different theories of learning that can be employed in the planning of educational activities.

Socio-cultural theory focuses on the causal relationship between social interaction and the individual's cognitive development. This approach comes from Vygotsky's zone of proximal development; that considers new knowledge derived from social interaction between a student and somebody more experienced or more capable.

This means that what is learned during the collaborative effort with a teacher would be used when the learner tries a similar problem independently.

Shared cognition theory introduces context as a new variable in the learning process, i.e., the social and physical context where learning takes place are important variables to take in account. Situated cognition approach has the advantage of link together specific contexts and the knowledge to be learned. According to this approach, collaboration is viewed as a process of building and maintaining a shared conception of a problem, in which knowledge is learned in applied situations.

These two approaches are explored in the web-based system conceived to teach architecture and described in this paper. The contextual parameters associated to each instructional unity provide knowledge from different contexts of use, and a focused forum allows the building of Vygotsky's zone of proximal development through discussion between students and the teacher. Structure discussion recorded in the forum is part of the cooperative problem solving process in which students identify contextual knowledge that intervenes in the process.

The web-based system also provides the integration between the main task and the conceptions discussed by participants, i.e, the graphical representations are attached to the arguments posted. It is argued that there is a contextual divorce if argumentation in design is not integrated with design spatial representation (Giboin, 1999; Shum, 1997). Giboin stresses that "without the ability to relate construction and argumentation to each other, discussing the solution is impossible. Without construction situations, design rationale cannot be contextualized".

It is common sense that the practice of architecture education is not integrated, being a set of independent disciplines that are supposed to be interlaced in the *atelier* practice (Borges, 1999). The *atelier* is a physical place, a classroom provided with the facilities to follow design activities, as well as a learning environment in which a project is assigned to architecture students. Complexity and difficulty of projects increase as the course progresses. The *atelier* can also be considered similar to a "community of practice" in the academic environment, in the sense that most of the teams are executing "real work," they are sharing common tasks, they have a common area of expertise, and they are engaged in searching for solutions to common problems.

Architects argue that architecture has a great deal of creativity and that the architectural knowledge cannot be formalized and structured. Teaching is done by case-based design in *ateliers*; teachers assess their students' conceptualizations and propose solutions that are not explained. Personal choices and intuition are the criteria invoked in architecture to judge project solutions. Engineers and architects are inductive learners and approach the problems in a holistic way in which a new experience is integrated as compiled knowledge in the body of already capitalized knowledge. Compiled knowledge is implicit knowledge that is not easily and directly explainable; it is like a context in which the new experience is embodied.

In other words, the *atelier* is an opportunity to turn explicit a part of tacit knowledge (ETK) and simultaneously allows sharing the implicit tacit knowledge (ITK) that is part of the teacher's repertoire. The role of teaching architecture in *ateliers* is two folds, i.e., the teacher helps students to identify the relevant contextual knowledge that refers to a task, and aid them in building their proceduralized context to the task at hand.

4. Architectural Contextual Library

The architectural contextual library (ACL) is a web-based system that supports the teaching of architecture in a contextualized basis, enhancing the design activity making knowledge available to users. Students are encouraged to build their own

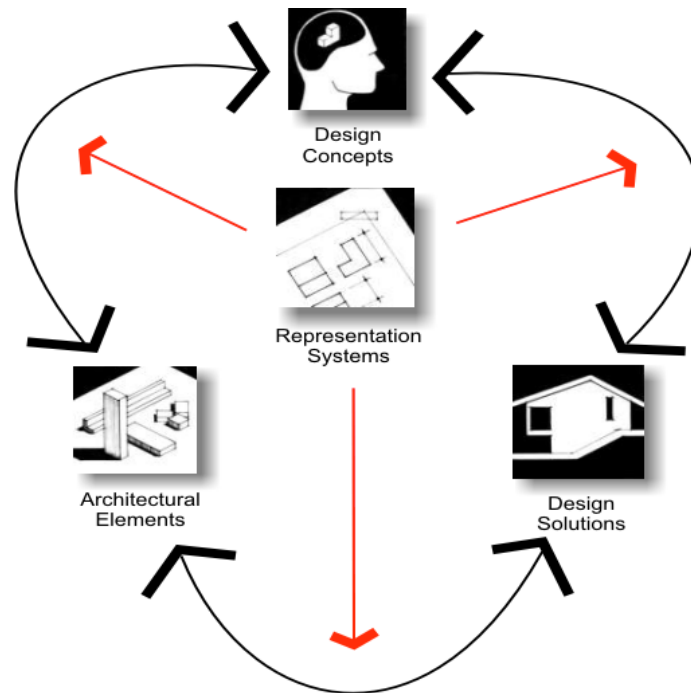
interpretative context by exploring the problem with the facilities provided by the system. Two functionalities are packed in ACL, the users' possibility of gathering context knowledge that intervenes in the design of a building element, and the facilities to discuss with experts to clarify the problems and identify what pieces of knowledge they need.

It was conceived by considering three main building blocks: architectural elements, design concepts and design solutions. The first one is composed of the physical elements of a building, the second represents the articulation of the main elements with specific and typical situations and the third one presents some solutions that integrate the prior ones.

Architectural elements represent the common knowledge on functional elements of a building. It is the language that architects refer when naming parts of the whole, the declarative language that describes the general properties of architectural elements in a sharable way. The architectural elements share an encoded graphical language for spatial representation that is part of the architect repertoire. They are the invariant portions of a building; every house has doors, windows, etc. Some architectural elements can be grouped by function, as follows: structural elements (columns, beams, slabs); insulation elements (walls, roofs), horizontal and vertical circulation elements (stairways, ramps, corridors).

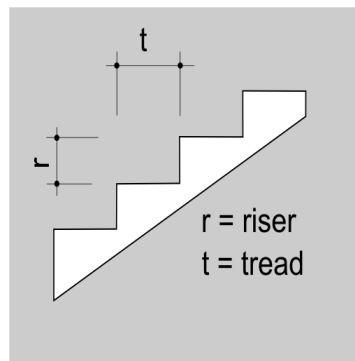
The second issue is focused on the relationships between the architectural elements in applied situations. It is called design concepts, and embodies contextual knowledge related to constraints and requirements of each architectural element, associated to the spatial relations that must be established between them in order to have functional integrity. Each architectural element can be viewed from different contexts and the interdependency between them is explained by textual and visual media. This explanation corresponds to the part of the contextual knowledge invoked and situated within the problem at hand, which has been prior called the procedural context associated to the decision process.

The third issue is a set of best practices embodied in concluded projects, which reflects the articulation between the former two aspects and represent prototypical situations or instantiations for assigned problems. As already stressed, the process of proceduralization requires reasoning about causes and consequences that are experimented in case-based dissection. This module is called design solutions, and it is composed of explanation texts, raster images and vectorial drawings.



Architectural Contextual Library (ACL)

If we take as example the element "stairways" one can identify all declarative knowledge related to it, despite the type or style of the stairway chosen. These pieces of knowledge are composed, for instance, by the number of steps needed for a given height, associated with the tread width and the riser height. This type of information, associated to ergonomic and constructive aspects that define the comfort, cost and accessibility of a stairway are available to students as a means of a multi criterion approaching for the subject "stairways".

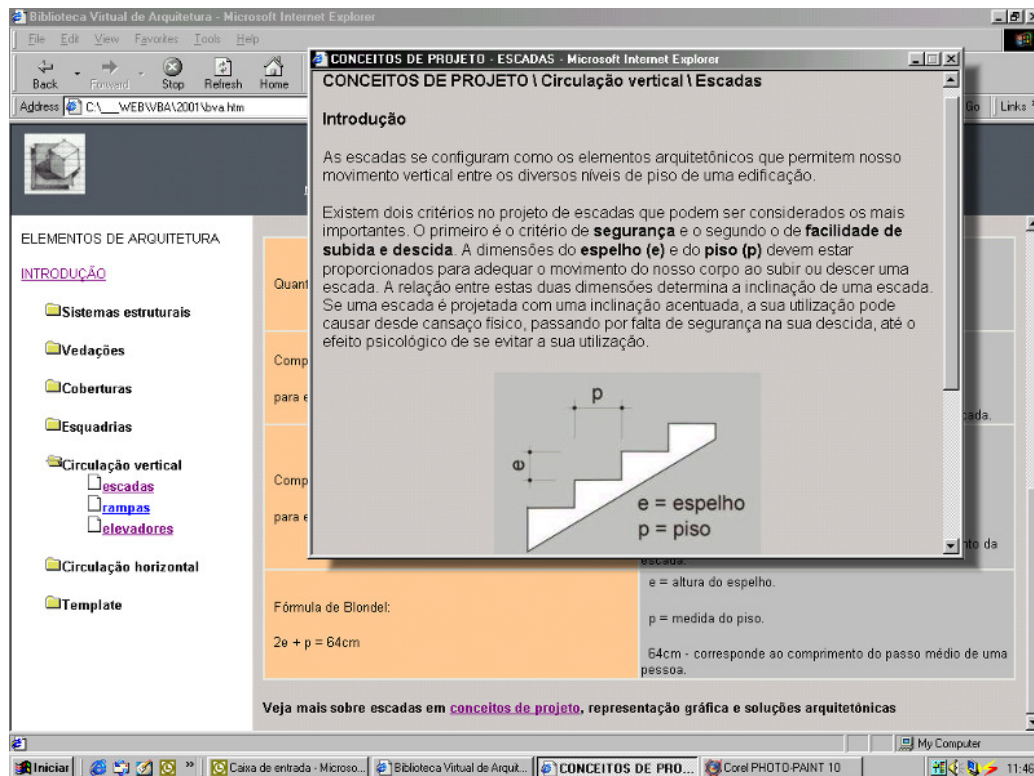


Geometric relations of a stairway step

The role played by stairways in a project is very complex as it is related directly with the circulation paths of people in a building and with the architect intentions in fulfilling the space. There are several types of stairways (straight run, U-type, L-type, spiral, etc.) and they can be treated differently by the architect. They can be additive, they can follow the edge of a stage, or they can just fulfil an empty volume.

In the Architectural Contextual Library this knowledge about stairways is grouped under design concepts and is presented as partial solutions where the attribute at hand is highlighted. Hypertext format is used to allow the student built his personal learning process, beginning by identifying relevant knowledge that is needed. On the other hand, the proposed situation assigned to the students is incomplete and they need some help to find out the problem in order to solve it.

An example of an ACL screen is presented below for the stairway case.



As stressed by Karsenty, "explanation must be conceived of as part of a cooperative problem solving process and not just a parallel phenomenon that does not modify the course of the reasoning" (Karsenty & Brezillon, 1995). The process of explanation should be viewed as a negotiation of meaning, i.e., accordingly with the situated cognition approach, in which the design rationale is learned in applied situations.

The forum provided as part constituent of the ACL fulfils the need of communication between novices and more experienced people. It offers a collection of cooperation and communication mechanisms that clarify the argumentation that takes place in the design process. It allows the structuration of the design problems, the maintenance of consistency in decision-making, and keeping track of decisions. Besides this, argumentative processes are a powerful way of discovering the structure of wicked problems, as those presented in design.

Visual reasoning is embedded in the ACL forum permitting spatial argumentation to be integrated in the design discourse avoiding context divorce to arrive. ACL is a web-based application in which drawings, sketches and schemes can be edited by image viewers.

5. Conclusions

Architecture practice is a knowledge intensive activity which involves an incremental learning process as part constituent of architects' activities. It is also considered as a social process, an environment for negotiation and decision, in which collaboration and communication play an important role in the goal of designing a building.

Practical knowledge and theoretical assets are present in the knowledge-based architectural process, and the notion of "practicability" is particular relevant in architecture as it needs apprenticeship to be learnt. This is a very important issue, because architecture expertise is developed by doing, i.e., in an environment where tacit knowledge can be shared among participants.

The notion of context used in this article offers an alternative view to situated

cognition situations, in which building and maintaining a sharing conception of a problem is integrated by the interpretative context in applied situations. The notion of context explored in this paper also offers a model to understand the links between decision making and/or action and the backstage knowledge involved.

The ACL instrument is an alternative to virtual libraries, which do not take in account contextual data and design rationale in their knowledge organization. ACL is a powerful way of enhancing learning effectiveness profiting the recent improvements observed in browsers and in the communications technology sector.

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