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COMPUTATIONAL LEARNING AND DESIGN ENVIRONMENT IN ARCHITECTURE

(Research article)

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Abstract

The computer has evolved from a tool to a privileged position where architectural design takes shape. Given that students are expected to work primarily in a computational environment and frequently in a collaborative way, some questions challenge and inspire us to consider new ways and methods that will aid in the creation and sharing of information and ideas. The dynamic of the architectural investigation process is the beginning point for our research, which aims to stimulate the architectural exploration process through the design and implementation of a computational environment based on a library of referents. In this paper, we try in particular to understand the characteristics of the design environment in architecture, therefore concerning the description and references of the library in the design dynamics. The referents' representation is viewed as a collection of descriptions in a distinct format. It is available to students and allows for new interpretations, interaction with their content, and eventually, knowledge acquisition during the architectural investigation process.

Keywords: Architecture design environment, precedent, representation, learning, pedagogy.

1. Introduction

The computer has evolved from a tool to a privileged location where the architectural design takes shape. Given that students are expected to work primarily in a computational environment and frequently in collaboration, some questions challenge and inspire us to consider new ways and methods that will aid in the creation and sharing of information and ideas (Heylighen and Segers 2002).

The goal of a research project aimed at the conceptualization, implementation, and testing of a computational environment based on a library of referents is to stimulate digital exploration processes and enhance design learning in architecture. (Iordanova 2009). The word referent is a catch-all term that combines metaphor and precedent. We specifically looked at the description of 3D models and the role of a library of referents in design dynamics as part of this research to try to figure out what makes a computational design environment in architecture interesting. The representation of referents is a collection of descriptions that allows students to recognize the models' potential, give them meaning, and interact with them. Finally, this information must be integrated into a process of investigation and search for architectural solutions. The questions relating to the computational design environment and the referent library are dealt with jointly to define a learning space for architectural design.

2. The Concept of A Computational Learning And Design Environment In Architecture

Many problems are inherent in the construction of a computational design space that is open and fitted to the processes of ideation and exploration in a project design scenario in architecture, according to the literature. The dynamics of the student's engagement with the project design situation's resources (Schön 1994), including his design space, instruments, and all the resources involved in his approach, are extremely difficult to translate into a digital setting. At the perceptual, gestural, and cognitive levels, limits are revealed (Guité 2007; Kalay 1999; Lawson 2006; Tang and Gero 2001). The dynamics of project design are described by

Schön (1994) as a reflective conversation. The student's eyes become more refined and his comprehension of the project grows as the explorations on specific components of the project proceed. In this iterative work of reading and appropriating the project reality, the student draws inspiration from projects carried out by others and from various sources. As a result, precedents are used in this procedure. It's worth noting that the precedents must contain different representations to assist the initiating of an idea and fully participate in its evolution. This need was taken into account throughout the construction of the referent library.

2.1. The Computational Learning Environment

The term "computational learning environment," or CLE, refers to a collection of technology environments designed to make teaching and learning easier. CLEs, which were originally meant to convey information, have evolved into distant communication and collaboration environments, resulting in the emergence of learning communities (Henri and Lundgren-Cayrol 2001). The CLE has evolved into mostly dynamic learning environments. The expansion of resource areas, the addition of communication and collaboration capabilities, and eventually the sharing of tools and information all represent this shift. According to Loiselle (2003), a training environment, which includes the continued use of digital technology, must include some features to encourage rich and autonomous learning. He mentions the following aspects:

- offer an open space of material and human resources;
- Assist students in developing their material and encouraging the development of group content;
- provide access to research and information organization tools;
- use multiple modes of representation;
- offer a variety of learning activities;
- establish a communication network between students;
- provide access to learning monitoring tools.

Project-based learning requires the use of environments that bring together all of these aspects, paying particular attention to the visualization of the stages taken by the student in the project process (Guité 2007) and the ability to interact with the various resources including precedents to interpret them (Léglise 2001) and integrate them into the project design process. According to Woodbury and Burrow (2003), the computer's potential may be used to simplify access to, visualization, and modification of representations of multiple solutions established. in the context of architectural design.

2.2. Cognitive aspects of learning

Iordanova and Tidafi (2007) conducted a review of the literature on cognitive elements of learning and highlighted several key criteria to consider for successful learning. Thus, the studies carried out inside the framework of a concept's definition, meaning the many alterations wrought, aid in the permanent construction of "categories of knowledge." This is reminiscent of the process of making in the design world which, according to Schön (1983), is at the heart of architectural design. The "objects" that occupy this design space modify how the designed object is represented.

Another attribute needed specifically for a learning environment is the ability to describe architectural solutions or more general knowledge using explicit rules, even if these are notions that experienced architects deal with instinctively (Oxman 2006). The coexistence of multiple representations of the same object, some of which are explicit and others more schematic, allows you to look at the same element of knowledge differently. The multimodality of representation of an object makes it possible to solicit different cognitive centers and thus facilitate the appropriation of knowledge and ultimately enrich learning. Another strategy to enrich the learning experience is to encourage students to work in their "proximal zone" of development (Vygotsky 1978). In this case, students are called upon to carry out tasks that exceed their capacities when they work independently, but which become achievable with the help of peers or devices designed for this purpose. An optimal learning environment should take these cognitive aspects into account.

2.3. Computational design environment in architecture

The notion of a computational design environment in architecture (Guité 2007; Engeli and Mueller 1999) is based on four key aspects:

- The description of the contents. Each representation must be accompanied by a set of information describing the content.
- The representation of the progress of the project design process. This element is concerned with the recording of modifications made to the project over time, as well as the system's ability to capture and depict the development of these changes. The multiple perspectives offered by such an environment make work visible. Several levels of consultation and visualization are sought, on the one hand, concerning the individual by identifying only a specific contribution and, on the otherhand, concerning the teamwork by illustrating the project in its setting.
- Interaction with the computational workspace and the various resources that make it up. This aspect concerns the multiple possibilities of navigation within the system, access to different representations, and different ways of interacting and manipulating representations.

Certain components of the design environment are private, while others can be shared, as seen by the traits described above.

2.4. Examples of existing environments

The expansion of the Web, combined with the inherent ability of computers to store and process large amounts of data, has led to the development of many precedents banks. Images are the most common way of describing anything. (Koutamanis et al. 2007), These precedent collections provide restricted representations while providing access to huge content spaces. Many research is aimed to go beyond the limits imposed by image databases. This is particularly the case with the dynamo system (Dynamic architectural memory online) designed as a library based on dynamic online memory (Heylighen, Heylighen, Bollen and Casaer 2005). The Dynamo system, which is hypermedia-style design assistance, is influenced by precedent-based techniques and the notion of dynamic memory. It provides a well-structured and well-organized collection of projects that can be shared and reused. Various graphic representations and related descriptions are used to document the projects. Similar goals are pursued by the Kaleidoscope system (Scaletsky 2004), which proposes the use of external references to encourage new ideas throughout the design process. Unlike previous systems, external references are not strictly associated with architectural projects. They are represented by images and come from various sources. This system uses analogical reasoning to allow the user to correlate his interpretation with the selected pictures, changing data into knowledge that can be used in the design process.

Based on the work of Christopher Alexander, Woodbury, Aish, and Kilian (2007) propose parametric models, "Design Patterns", offering generic solutions to solve well-defined problems. Models contain a set of information allowing the designer to recognize the relevantmodel in response to a given situation. This information comprises the model's name, a description of its functions, the sort of problem to be solved, application contexts, and an explanation of the model's benefits. and finally examples of use. The designer has several types of representations to understand the possible use of these models and integrate them into his design process. "Design Patterns" is the only reference base that offers dynamic models with access to source code, allowing direct reuse or know-how translation of a creative process, according to the research. In discussing the nature of the design environment, Woodbury and Burrow (2003) state that access to resources is the most important factor to consider in assuring its success. Using digital techniques, the authors develop navigation strategies in this "space" to amplify architectural exploration. They envision two types of representations: strong and weak, the first being more concrete and the second more abstract and implicit. They believe that a good depiction should be neither too powerful nor too weak to allow for interpretations and connections. The reflections of Fischer (2007) on various sorts of representations all lead in the same direction. They allow an interlocutor to "create meaning" from a topic that has been presented.

3. The Proposed Environment

Through this research, we consider that to support the student's reflexive approach (Schön 1994) and increase the exploration potential in a project design situation, it is necessary to offer a computational environment that fully supports the dialogue that the student maintains with the resources and the multiple representations of his project. We have the following three levels of interaction:

- The level of referent representations, which considers the possibility of modifying and evolving them towards the thing being created;
- The level of an interactive referent library, which is equivalent to a device for sparking thoughts and transmitting knowledge;
- The levels of a design space offer the possibility of associating referents andtools and thus allowing the evolution of the project.

3.1. Interactive Models: Objects to Think

Based on the need to offer multiple representations of the concepts to be explored and transformed, as well as on the importance of explaining know-how, the referents were described using various formats: text, image, animation, parametric model, etc. (Iordanova et al. 2007, Iordanova 2009). Thus, knowledge and skills about different design processes or even concerning building science can be described and represented by interactive models (Figure 1). The parametric nature of the model makes it possible to express links between the elements, while algorithmic expressions can represent rules. Each model is representative of the digital method leading to its creation and can be modified in coherence with it. Objects and their parameters may have architecturally significant names, but may also be reinterpreted and used for other purposes, thereby responding to Fischer's (2007) concerns about the transfer and the creation of meaning.

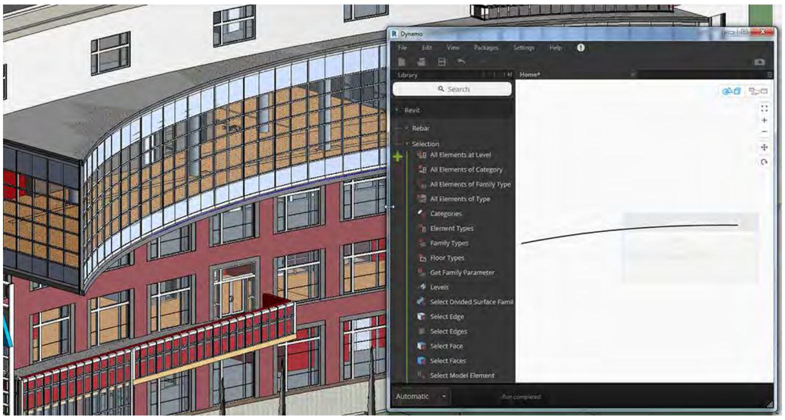

Figure 1. two instances resulting from the interactive exploration of a model andrepresenting a possible link between the structure and the skin of a building.

Thus, referent models constitute a digital material that the student can manipulate from a set of parameters based on principles of morphological transformation defined concerning environmental phenomena or more freely to movements in space. The student has a library ofdynamic models and thinks from the representation of processes (Oxman 2008).

3.2. Digital library: the palette of tools

The interactive referents are organized in a library which allows an overview and offers a variety of methods and encapsulated knowledge (Figure 2). Referents with "weak" representation (schematic and interactive models) coexist with referents with "strong" representation (which illustrate concrete architectural precedents). The following aspects were considered in the development of the library:

- The precedents' degree of abstraction must be high enough to allow for different readings while yet being meaningful to students. Too low a level of abstraction would lead to the representation of explicit models.
- The description of the precedents in the library has the function of translating the content and the interpretation of the designer. The possibility of students sharing and reusing models.

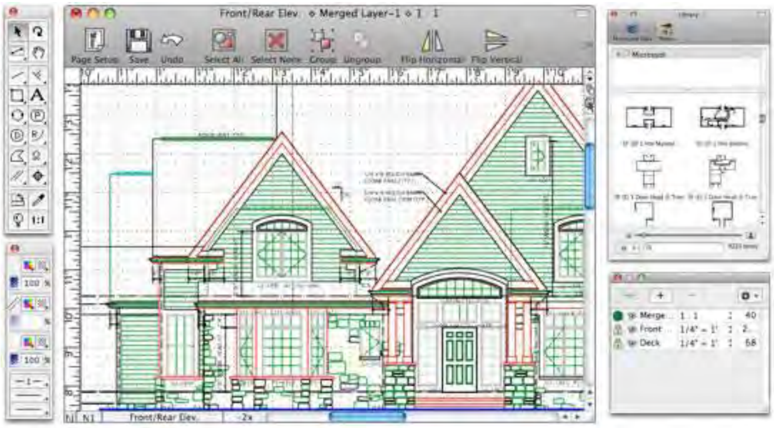

Figure 2. excerpt from a web page displaying a list of the library's referents: cohabitation of "weak" and "strong" representations

A series of themes may be used to search through the library's contents. Referents are associated with themes relating to (1) digital methods and techniques for creating a shape,

(2) knowledge of the structure of the building, (3) know-how about energy performance, acoustic or bioclimatic construction, (4) urban rules, (5) creative understanding, and so forth. (Iordanova et al. 2007). Thanks to the representations of the processes based on interactive models and associated algorithms, the library offers potential for the transfer of know-how. A prototype of the library grouping more than fifty interactive architectural referents (LibreArchi) was produced using Maxon's Cinema4D software modeling space (Iordanova 2009).

3.3. Computational environment: design space

The computational environment is a container for multiple representations of the project, individual and collective, and a space in which the student can use different tools to navigate, search, visualize, explore and build their content while enriching collective content (Guité 2007). Interactive models make up the referent library. By being thus associated with 3D modeling tools and linked to a palette of analysis resources and computational representations inherent in the computer, we believe that a library of referents is likely to become an organizing nucleus of the digital space. learning and design of an architecture student. Among different means and strategies allowing the student to explore, to retrace the steps taken in exploration, to organize the elements of a design object, or even to establish links between the produced representations, the library of referents is called upon to play a key role. Tunçer (2006) points out that through annotation, research, and access to multiple representations of a concept, a computational design environment can emerge (Figure 3).

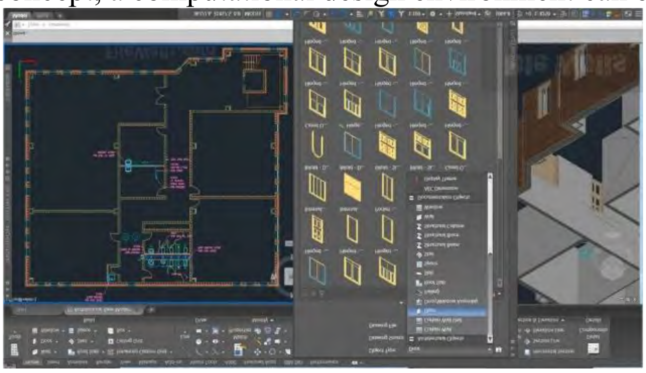

Figure 3. exploration of the referent library through the interfacemodeling software: a direct link between referents and software

The prototype referent library is a space for sharing between students of a studio and the tutor. The tutor and the students can consult and download objects from the library (Figure 2). They also have the right to modify and add components. In addition, the student can appropriate the library can annotate referents and add others in this scenario. He can also use the environment offered by the library to keep track of his explorations or projects (Figure 3).The ability to interactively maneuver a model greatly enriches the architectural exploration process.

4. OBSERVATIONS IN A LEARNING SITUATION

The observations were carried out with four groups of ten students enrolled in the undergraduate and graduate programs in architecture at the University of Sétif from 2018 to 2019 (Ali chougui 2019). In order not to change the current learning situation in the studio, observations were made throughout the semester and semi-directed questionnaires were completed by the students at the end of the semester.

4.1. Students' appropriation of the library as an organization of their digital space

The exploitation of the library of precedents was an opportunity to consolidate skills relating to the organization of the digital space. In this context, the appropriation of the library varies according to two factors.

We noticed that students who already had strategies for organizing their digital files were more easily engaged in the operation of the library. Furthermore, the methods of integration into the design process also have a great influence. According to the direct observations of the tutor, who is one of the researchers who conducted the study, when the library is presented as the digital strategy to adopt from the start of the studio, the appropriation is widespread and more in-depth. Several levels of appropriation of the library have been identified:

- as a means of organizing project files;
- as an example for organizing directories on the computer;
- and to adopt strategies to safeguard the stages of the project.

4.2. Usage scenarios in project design

The scenarios of use of the referent library vary according to the stages of progress of the design studio, the particular interests of the student, and the cognitive strategies adopted:

- The referent library is frequently checked at the start of the quarter to learn more about the digital medium's capabilities.
- • Models are manipulated and rebuilt to get a better understanding of them and to improve computational technique learning.
- The adoption of models reflecting domain knowledge is sought when creating the project and working on its many architectural features. However, for the moment the

  the prototype does not offer many variants on this theme and the use of the library islimited.
- Students frequently go to the library to look for a solution based on the concrete foundations provided by 3D models.
- Some students are inspired by the forms proposed by the referents. They explore theimages, transform the models and produce several variants.
- Often, students seek ideas for methods and processes. This procedural knowledgecould eventually be used in new projects.

The observations revealed the importance of the referent library in the process of learning 3D modeling and specifically of digital strategies aimed at enriching the exploration and project design processes.

4.3. Interaction with the library and adding models

The questionnaires revealed that a majority of students welcome the possibility of contributing to a library of referents and sharing knowledge through a collective space. However, engagement in this collective achievement cannot be done without sustained support from the tutor. This collaboration requires time from students. On the other hand, some are reluctant to contribute to the library due to copyright, while others do not value theirmodels enough to share them. We wish to enrich the process of collective construction of thisspace.

4.4. Assessment of the role of the library

The observation of students in design situations and the survey carried out using questionnaires reveal a great utility of the library of referents in support of learning digital methods of project design. For some students, the library has sparked ideas whose impact is evident in the projects. Specifically, we noticed that the library plays a role in the creative process through the computational methods conveyed by the models. Thus, the parametric methods of creating an object have been exploited to energize the exploration of an object, the search for solutions, and the emergence of ideas caused by the models and the tool (Iordanova 2009).

We have identified three levels of use of referents:

- free use, separated from the constraints of the project;
- direct use, by transferring methods and processes from a referent to the current project;
- an application of the referents' principles to the current project.

For a majority of students, free use of the referent library is an effective way to improve the learning of 3D modeling and a set of computational strategies. A student participating in the study said, «It feels like we have a teacher at home. » However, direct uses and transfers are the two levels of appropriation sought for the referent library. The results of the survey show us that improvements must be made to the library to meet these objectives. Aside from the limited number of referents currently available, student comments tell us that the descriptions of the objects are not sufficient to discover the full potential offered by the models. In addition, the parameters that govern the control of the form are too numerous, which has the effect of engaging the student in explorations that are sometimes too laborious to support a creative process. Finally, the ergonomics of the interface must be relaxed to allow more fluidic navigation through the multiple representations of the referents.

5. CONCLUSION

The results of this research allow us to identify the characteristics that must be taken into account in the development of a digital library of referents and to consider this resource at thecenter of the student's learning and design environment. In our opinion, it manages to play an important role in learning, in particular by encouraging a majority of students to work in their «proximal zone» of development. The referent library was a source of inspiration for some students while others used it functionally, as the aid of a digital method of building 3Dmodels. The findings of this study are influenced by some variables. Some relate to the students' prior knowledge and encourage us to revise the skills in the use of digital technology to be developed from the first years of training in architecture. Other factors concern the environments and tools used for the referent library. In addition to the improvements identified, we wish in the next stages of development of the referent library to extend the use of this environment to all the design studios of the school of architecture and to the various courses likely to benefit from a set of models. representing know-how and architecture knowledge. Given the wider use of the referent library, the knowledge required for tutors and teachers should be considered.

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