International Journal of Research in Education Humanities and Commerce

Volume 01, Issue 03 " September - October 2020"

COMPUTATIONAL LEARNING ENVIRONMENT AND DESIGN IN ARCHITECTURE

Dr ALI CHOUGUI
Maître de conférences « A »
Laboratoire Habitat & Environnement
Institut d'architecture et des sciences de la Terre
Université de Sétif -1-

ABSTRACT

The computer is more than an instrument, it has become the privileged place where the architectural design takes shape. Considering that students are called upon to work mainly in a computational environment and most often in collaboration, several questions challenge us and encourage us to think about new approaches and new means likely to support the process of creation and sharing of knowledge and ideas. The dynamism of the process of exploration in architecture constitutes the starting point of our research which aims at stimulating the exploration process in architectural design through design and creation of a computational environment centred on a library of referents. In this paper, we try in particular to understand the characteristics of the design environment in architecture, therefore with regard to the description and references of the library in the design dynamics. The representation of the referents is seen as a combination of descriptions in a different format. Offered to students, it allows for new interpretations, for interaction with their content, and finally, for the integration of knowledge during the process of architectural exploration.

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

1.0 INTRODUCTION

The computer is more than an instrument, it has become the privileged place where the architectural design takes shape. Considering that students are called upon to work mainly in a computational environment and most often in collaboration, several questions challenge us and encourage us to think about new approaches and new means likely to support the process of creation and sharing of knowledge and ideas (Heylighen and Segers 2002).

The desire to energize digital exploration processes and improve the design learning in architecture constitutes the starting point of a research project aiming at the conceptualization, the realization and the testing of a computational environment centred on a library of referents (Iordanova 2009). The term referent is generic and brings together the concepts of metaphor and precedent. Through this research, we notably tried to define the characteristics of a computational design environment in architecture by taking a specific look at the description of 3D models and the role of a library of referents in design dynamics. The representation of referents is considered as an amalgam of descriptions allowing the students to recognize the potential of the models, to give them meaning, to interact with their

content and finally to integrate this knowledge in a process of exploration and search for architectural solutions.

The questions relating to the computational design environment and the referent library are dealt with jointly in order to define a learning space for architectural design.

2.0 THE CONCEPT OF A COMPUTATIONAL LEARNING AND DESIGN ENVIRONMENT IN ARCHITECTURE

The literature informs us of many challenges inherent in the development of a computational design space open and adapted to the processes of ideation and exploration in a project design situation in architecture. The dynamics of the interaction between the student and the resources of the project design situation (Schön 1994), including his design space, his instruments and all the resources involved in his approach, is very difficult to transpose into a digital context. Limits are manifested at the perceptual, gestural and cognitive levels (Guité 2007; Kalay 1999; Lawson 2006; Tang and Gero 2001).

Schön (1994) describes the dynamics of project design as a reflective conversation. As the explorations on particular elements of the project progress, the student's eyes become more refined and his understanding of the project is built up. 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. This process, therefore, involves the use of precedents. Note that to support the triggering of an idea and participate fully in its development, the precedents must include multiple representations. We have considered this requirement in the development of the referent library.

2.1. The Computational Learning Environment

The concept of computational learning environment, CLE, is used to refer to a set of technological environments developed to facilitate teaching and learning. Originally designed to transmit information, CLEs have become remote communication and collaboration environments, leading to the creation of communities of learners (Henri and Lundgren-Cayrol 2001). The CLE become environments mainly dedicated to dynamic learning. This change is reflected in particular by the unfolding of resource spaces, by the addition of means to communicate and collaborate, and finally by the sharing of tools and documents. Loiselle (2003) emphasizes that a training environment, including the sustained use of digital technologies, must bring together a certain number of characteristics to promote rich and independent learning. He mentions the following aspects:

- offer an open space of material and human resources;
- help students develop their own content and encourage the enrichment of collective 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 which 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 in order to interpret them (Léglise 2001) and integrate them into the project design process. Woodbury and Burrow (2003) point out that the potential of the computer can, in particular, be exploited to facilitate access, visualization and manipulation of representations of several solutions developed in the context of architectural design.

2.2. Cognitive aspects of learning

A review of the literature on cognitive aspects of learning (Iordanova and Tidafi 2007) identified some important points to consider for successful learning. Thus, the explorations carried out within the framework of the definition of a concept, implying the multiple transformations brought about, help to construct "categories of knowledge" permanently. This is reminiscent of the process of making in the design world which, according to Schön (1983), is at the heart of architectural design. "Objects" that populate this design space change the representations of the object being designed.

Describing architectural solutions or more general knowledge by explicit rules, even if these are concepts that experienced architects tackle implicitly (Oxman 2006), is another characteristic sought especially for a learning environment. 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 centres and thus facilitate the appropriation of knowledge and ultimately enrich learning.

Another strategy to enrich 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 which 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 concept of computational design environment in architecture is based on four fundamental aspects (Guité 2007; Engeli and Mueller 1999):

- 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 aspect concerns, in particular, the recording of changes made to the project over time and the means offered by the system to capture and visualize the progress of these transformations.
- The multiple perspectives offered by such an environment to make work visible. Several levels of consultation and visualization are sought, on the one hand, with reference to the individual by identifying only a specific contribution and, on the other hand, with reference to the teamwork by illustrating the project in its setting.

- Interaction with the computational work environment and the multiple resources that compose it. This aspect concerns the multiple possibilities of navigation within the system, access to different representations and to different ways of interacting and manipulating representations.

From the characteristics listed above, it is possible to notice that certain aspects of the design environment are private, while others can be shared.

2.4. Examples of existing environments

The expansion of 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. Most often described by images (Koutamanis et al. 2007), these collections of precedents offer limited representations while giving access to vast spaces of content. Many research are aimed to go beyond the limits imposed by image databases. This is particularly the case with the dynamo system (Dynamic architectural memory on-line) designed as a library based on dynamic online memory (Heylighen, Heylighen, Bollen and Casaer 2005). Considered as a hypermedia-type design aid, the Dynamo system is inspired by precedents-based approaches and the theory of dynamic memory. It offers a structured and organized set of projects to share and reuse. The projects are documented by various graphic representations and associated descriptions.

The Kaleidoscope system (Scaletsky 2004) has similar aims by proposing the use of external references to stimulate new ideas in 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 is based on analogical reasoning and allows the user to associate his interpretation with the chosen images, thus transforming the information into knowledge mobilized 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 relevant model in response to a given situation. This information includes the name, descriptions of the functions of the model, the type of problem to be solved, application contexts, an explanation of the advantages of using this model 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.

Following the research undertaken, "Design Patterns" is the only reference base offering dynamic models with access to source code and allowing direct reuse or know-how transposition a creative process.

Referring to the structure of the design environment, Woodbury and Burrow (2003) point out that access to resources is the key parameter to consider in ensuring the success of such an environment. Using digital techniques, the authors develop navigation strategies in this "space" in order 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. A good representation, according to them, should be neither too strong nor too weak to allow interpretations and associations. Fischer's (2007) reflections on different types of representations point in the same direction. They give an interlocutor the possibility of "creating meaning" from a communicated concept.

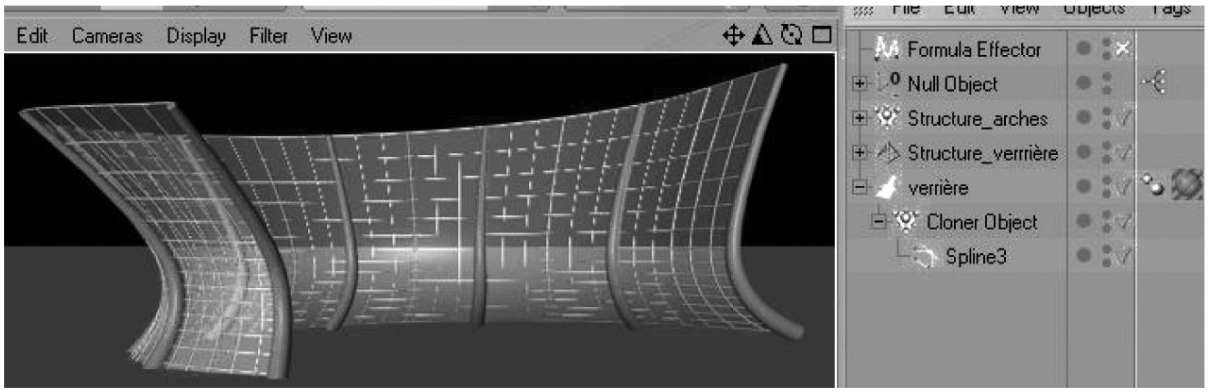
3.0 THE PROPOSED ENVIRONMENT

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 representations of referents by considering the possibility of transforming them and making them evolve towards the object being designed;
- the level of the library of interactive referents, analogous to a device for triggering ideas and transferring knowledge;
- the level of a design space which offers the possibility of associating referents and tools 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 in relation to 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 (2007) concerns about the transfer and the creation of meaning.



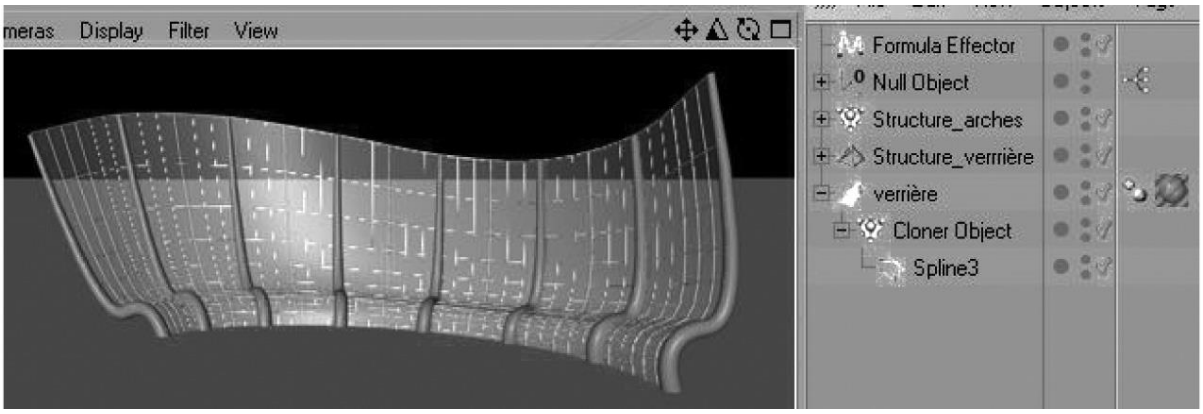


figure 1. two instances resulting from the interactive exploration of a model and representing a possible link between the structure and the skin of a building.

Thus, referent models constitute a digital material that the student can manipulate from a set of parameters based on principles of morphological transformation defined with reference to environmental phenomena or more freely to movements in space. The student has a library of dynamic 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 level of abstraction of the precedents which must be high enough to allow multiple interpretations while remaining meaningful for students. Too low a level of abstraction would lead to the representation of explicit models.
- The description of the precedents in the library which has the function of translating the content and the interpretation of the designer.
- The potential for sharing and reusing models between students.

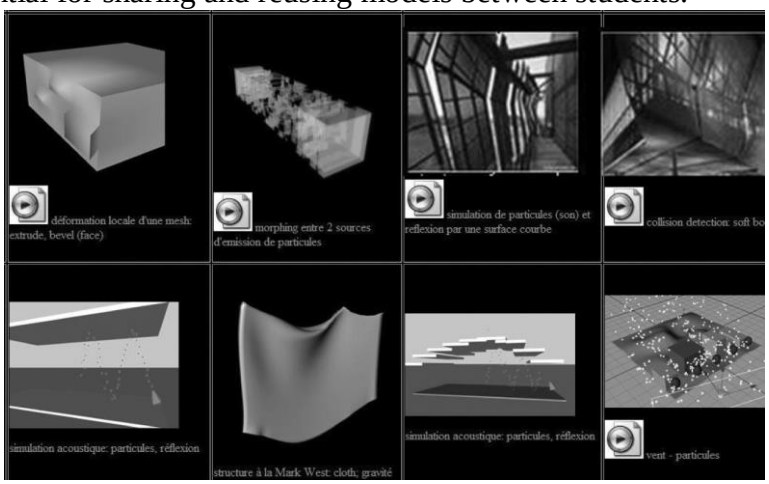


figure 2. extract from a web page showing an overview of referents of the library
: cohabitation of “weak” and “strong” representations

Searching through the content of the library can be done by a set of themes. 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 in relation to energy performance, acoustic or bioclimatic building, (4) urban regulations, as well as (5) artistic knowledge, etc. (Iordanova et al. 2007). Thanks to the representations of the processes based on interactive models and associated algorithms, the library offers potential for transfer of know-how. A prototype of the library grouping more than fifty interactive architectural referents (LibreArchi) was produced using Maxon’s Cinema4D software modelling 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 own content while enriching collective content (Guité 2007).

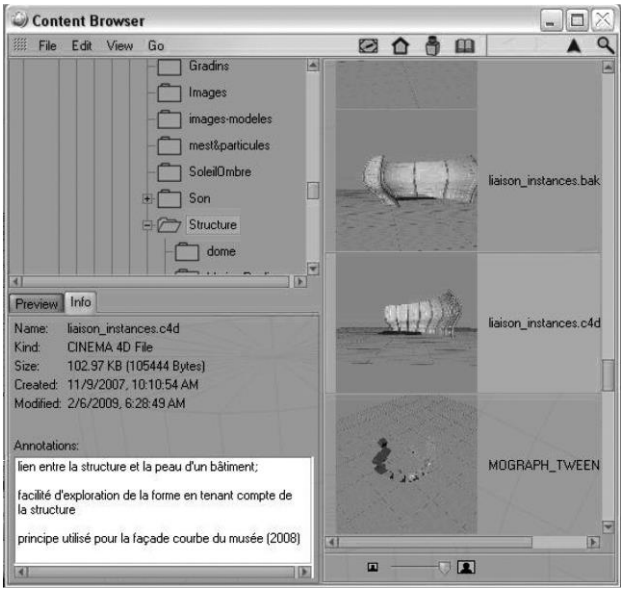


figure 3. exploration of the referent library through the interface modelling software: a direct link between referents and software

The referent library is made up of interactive models. By being thus associated with 3D modelling 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).

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 rights to modify and add components. In addition, the student can appropriate the library. In this case, he can annotate referents and add others. He can also use the environment offered by the library to keep track of his explorations or projects (Figure 3). The ability to interactively manoeuvre a model greatly enriches the architectural exploration process.

4.0 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 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:

- At the beginning of the quarter, the referent library is often reviewed to find out about the possibilities of the digital medium.
- Models are maneuvered and reconstructed in order to better understand them and improve the learning of computational methods.
- In developing the project and working on its various architectural aspects, the use of models representing domain knowledge is sought. However, for the moment the

prototype does not offer many variants on this theme and the use of the library is limited.

- Often, students refer to the library to explore a solution from concrete bases offered by 3D models.
- Some students are inspired by the forms proposed by the referents. They explore the images, transform the models and produce several variants.
- Often, students seek ideas for methods and processes. This procedural knowledge could 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 their models enough to share them. We wish to enrich the process of collective construction of this space.

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;
- a transfer of the principles inherent in the referents 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.

5.0 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 the centre 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 in a functional way, as the aid of a digital method of building 3D models.

The results of this research are dependent on a combination of factors. 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 studio of the school of architecture and to the various courses likely to benefit from a set of models. representing know-how and architecture knowledge. In view of the wider use of the referent library, the knowledge required for tutors and teachers should be considered.

RÉFÉRENCES

De Paoli, G. et Iordanova, I., 2005, Modèles, blocages et déclencheurs: l'enseignement de la conception architecturale et l'informatique dans Actes de la conférence internationale – Interdisciplinarité, art, architecture et ingénierie, Tunis 2005, 10 pages.

Engeli, M. and Mueller, A., 1999, Digital Environments for Learning and Collaboration – Architecture, Communication, Creativity dans Actes du colloque de ACADIA 1999, Salt Lake City, Utah, p. 40-52.

Fischer, T., 2007, Enablement or Restriction? On supporting others in making (sense of things) dans Actes de la conférence internationale: CAADFutures 2007, Sydney, p. 585-598.

Guité, M., 2007, Le Carnet numérique: Élaboration et validation d'un dispositif pédagogique dédié à la construction et à l'exploitation de la mémoire numérique dans la conception des projets en architecture, Rapport d'étude, Université de Sherbrooke, Sherbrooke, 204 pages.

Henri, F. et Lundgren-Cayrol, K., 2001, Apprentissage collaboratif à distance. Pour comprendre et concevoir les environnements d'apprentissage virtuels, Sainte-Foy, Presses de l'Université du Québec.

Heylighen, A., Heylighen, F., Bollen, J. and Casaer, 2005, A Distributed Model for Tacit Design Knowledge exchange dans Actes de la conférence de SID2005, 4th Social Intelligence Design Workshop.

Heylighen, A. et Segers, N.M., 2002, Crossing Two Thresholds with one Stepping Stone – Scenario for a More Comfortable Design Environment dans Actes de la Conférence de l'Association for Computer Aided Design In Architecture, Thresholds - Design, Research, Education and Practice, in the Space Between the Physical and the Virtual, Pomona, CA, 24-27 Octobre , p. 145-153.

Iordanova, I. et Tidafi, T., 2007, Multimodal representation of referents for the architectural design studio: some cognitive aspects. International Journal of Design Sciences and Tech¬nology, 14(2), p. 105-118.

Iordanova, I., Tidafi, T. et De Paoli, G., 2007, Is a Digital Model Worth a Thousand Pictures?, in Actes de la conférence internationale, CAADFutures, Sydney, p. 85-98.

Iordanova, I., 2009, Assistance de l'enseignement de la conception architecturale par la modé¬lisation de savoir-faire des référents, PhD Thesis, Université de Montréal, Montréal.

Kalay, Y., 1999, The Future of CAAD: From Computer-Aided Design to Computer-Aided Collaboration, in S. Llavaneras , F. et al. (dir.), 1ra Conferencia Venezolana sobre Aplicación de Computadores en Arquitectura, Caracas, p. 19-28.

Koutamanis, A., Halin, G. et Kvan, T., 2007, Indexing and Retrieval of Visual Design Repre¬sentations dans Actes du colloque de eCAADe 25, p. 319-326.

Lawson, B., 2006, How Designers Think, The Design Process Demystified, Oxford, Architectu¬ral Press (1re éd. 1980).

Léglise, M., 2001, Computer Stimulated Design: Construction of a Personal Repertoire from Scattered Fragments, International Journal of Automation and Construction (Special issue on Cyber Design, vol. 10/5), p. 577-588.

Loiselle, J., 2003, L'exploitation du multimédia et du réseau Internet pour favoriser l'autono¬mie des étudiants universitaires face à leurs apprentissages, in S. Alava (dir.), Cyberespace et formations ouvertes. Vers une mutation des pratiques de formation?, Bruxelles, DeBoeck Université, p. 99-110.

Oxman, R., 2006, Educating the Digital Design Thinker, in Actes du colloque de 24th eCAADe, Communicating Space(s), Volos, Grèce, p.198-205.

Oxman, R., 2008, Digital Architecture as a Challenge for Design Pedagogy: Theory, Knowledge, Models and Medium, Design Studies, 29(2), p. 99-120.

Scaletsky, C.C., 2004, The Kaléidoscope System to Organize Architectural Design References, International journal of archietctural computing, 3(2), p. 353-387.

Schön, D.A., 1994, Le praticien réflexif. À la recherche du savoir caché dans l'agir professionnel, (Trad. J. Heynemand et D. Gagnon), Montréal, Les Éditions Logiques. (1re éd. 1983).

Tang, H.H. et Gero, J.S., 2001, Roles of Knowledge while Designing and their Implications For Caad, in J.S. Gero, S. Chase et M. Rosenman (dir.) Actes de la sixième conférence de CAADRIA, Sydney, p. 81-89.

Tunçer, B. et Sariyildiz, S., 2006, Design Analysis Network: An educational environment for architectural analysis dans Actes du colloque de 24th eCAADe, Communicating Space(s), Volos, Greece, p. 206-218.

Vygotsky, L.S., 1978, Mind in Society, Cambridge, MA, Harvard University Press.

Woodbury, R., Aish, R. et Kilian, A., 2007, Some Patterns for Parametric Modeling dans Actes du colloque de 27th ACADIA Expanding Bodies: Art • Cities• Environment. Halifax (Nova Scotia), p. 222-229.

Woodbury, R. et Burrow, A., 2003, Notes on the Structure of Design Space, International Journal of Architectural Computing, 1(4), 517-532.

