Prototype of an Interactive Case Library for Architectural Design

Ann Heylighen[1], Raf Segers & Herman Neuckermans[2]
Catholic University of Leuven
Dept. of Architecture, Urban Design and Planning
Arenbergkasteel, B-3001 Heverlee (Leuven)
Belgium

ABSTRACT

Architects acquire an important part of their design knowledge from existing designs. Specific design projects from the past form an indispensable source of information and inspiration. Hence the idea to develop a digital library of design cases that can be easily accessed during design. The paper describes a recently developed prototype of such a case library, intended to assist architecture students in the studio, yet with the potential of expansion into the office setting. When students enrol into a design project, they usually receive a reader with some relevant examples. At first sight, the digital case library only seems to represent these examples into another medium, yet there are some important differences between both. Unlike the reader, the library has at its core an indexing-system which allows the easy retrieval of relevant information. By labelling projects with several features and making links between similar designs, the tool supports both directed search and browsing. A second difference is that the library is interactive. Students are not only able to consult interesting examples, but also to add other projects they consider relevant, to make links between them, to create extra indices etc. Finally, the tool allows to combine several media and to create links to external information sources.

1 INTRODUCTION

Architects and designers in general are assumed to acquire an important part of their knowledge through experience. Design experience can be interpreted in different ways. Strictly speaking, having experience in architectural design means having designed yourself. In a wider sense, visiting a building, i.e. physically experiencing the built object others have designed, can be seen as a form of acquiring experience too. Finally, apart from 'live' visits, architects often acquire knowledge about existing projects 'second hand' through pictures, drawings and text in magazines, books, etc. During the years, they have learnt to develop a mapping between these representations of a design and reality, which allows them to form an idea of the real building.

What all these interpretations of design experience have in common, is that there is a specific design in the play. Specific designs from the past form an essential source of information and inspiration in education as well as in practice. Teaching say architectural history would simply be impossible without design cases. The particulars in a given case

offer a holistic view of design issues that would be difficult to explain if they were taken up separately, which makes the specific case an excellent vehicle of discourse with the students (Dave et al. 1994). Also in practice, architects revisit previous projects in several stages of the design process, during the early conceptual phase as well as in the final development of working drawings.

Recognising the vital role specific cases play in architectural design, a whole variety of computer-based tools have been and are being developed, ranging from digital archives over intelligent libraries to case-based design systems. Digital archives do little more than representing architectural projects in a computer medium making search and retrieval more efficient than with conventional media. Intelligent libraries differ from these archives because of the high level of knowledge behind the representation, intelligent support for search, potential for browsing and cross-indexing when information sought is incomplete, etc. (Oxman & Oxman 1993). Even more 'artificially intelligent' are systems dealing with case-based reasoning in design such as FABEL (Schmidt-Belz & Hovestadt 1996) and SEED (Flemming et al. 1994) for building design, ACHIE and ARCHIE-II (Kolodner 1993) specialised in courthouse design and IDIOM (Smith et al. 1996) for apartment floor layouts. Not only do they represent design cases, they also take over (part of) the design process that makes use of them. Some of these systems aim at supporting architects during design, while others have the ambition to completely automate the design process.

2 AN INTERACTIVE CASE LIBRARY FOR THE DESIGN STUDIO

Convinced that fully automated design systems - whether case-based or not - are a dead-ended siding (Heylighen 1996), we decided to develop an interactive case library, at first stage for the design studio yet with the potential of expansion into the office setting. The tool is intended to assist (student-)architects during the early conceptual stage of design. As the first step in the design process, conceptual design is in some sense the most influential. Decisions made here have the largest effects and are the hardest to undo later. Moreover, many architects and most architectural students today seem to consider the 'concept' as the essence of architectural design. Thus, if we want to improve design, than conceptual design is certainly an area with a high pay-off.

The interactive case library tries to kill two birds with one stone. At short notice, it wants to provide (student-)architects with a rich source of inspiration, ideas and information, as it is filled with examples relevant for their own project. Its long-term objective is to initiate and nurture the life-long process of learning from existing designs. The trick is not only to use the cases in the library as a vehicle to help students design a better project, but also to use the project they are designing as a vehicle to pick up knowledge about previous designs along the way.

When students enrol into a design assignment today, they often receive a reader with relevant examples, usually copied from books and magazines. At first sight, the case library only seems to represent this reader into another medium, i.e. a computer. Yet, there are some important differences between both.

2.1 Open Structure

A first difference concerns the structure of the provided information. In case of the reader, the structure of the information is linear: one page follows another, one design project follows another. Two successive projects can be very similar in some respect and totally different in another. Stirling's Neue Staatsgalerie and Le Corbusier's Visual Arts Center, for example, share the same program and the same concept of 'path through', yet have realized this concept in quite a different way, i.e. as a ramp in the central court versus an elevated walkway through the building respectively (Oxman & Oxman 1993). Such complex connections between similar and dissimilar designs are not readily captured in the linear structure of the reader.

The structure of the case library, on the other hand, does support such connections. At its core, the library has an indexing-system that allows the easy retrieval of relevant information. Every project is labelled with several features - building name, concept, program, site, surface etc. - and linked to projects with common characteristics. The user can select each or a combination of these features as a filter to search the library for relevant projects. If we consider design cases as encapsulations of design knowledge, this labelling and linking further enhances each case's value. It allows the user to approach a design from different perspectives and to situate it in relation to other designs. Unlike the reader, the knowledge content of the library does not only reside in the cases it contains, but also in the way these cases are structured.

2.2 (Inter)Action

A similar structure could in fact also be applied to the reader. We would only need to include alphabetical lists of architects, building names, concepts, etc. at the back, pared with the page numbers of the corresponding projects. However, as clever and complete these lists might be, the reader would still be limited by its static nature. Just like a warehouse, it inventories information that can be consulted, yet these consultations leave the reader unchanged - except perhaps from dog-earing its pages. The case library, on the other hand, is conceived as an (inter)active workhouse rather than a passive warehouse (Schank & Cleary 1995): it is interactively developed by and actively develops its users' knowledge.

The library is interactive in the sense that the user cannot only consult cases already present in the library, he can also add new projects, make links between them,

create extra indices etc. The need for such open-ended approach to case collection and indexing derives from the specific nature of design. In design the problem definition grows parallel to the solution (Bruce Archer quoted in Neuckermans 1994), which makes it impossible to foresee which cases might be useful at the outset. The same applies to the features used to index these cases. Being involved in a new project, an architect may discover relevant concepts in a previous project he was not aware of before. For this and other reasons, it is highly questionable whether a previous design can be indexed once and for all by its underlying concept(s) (Heylighen 1997). Making the library user at the same time librarian has the advantage that the library can draw on the user's knowledge to permanently nourish its content and refine its structure so as to stay in tune with his evolving needs and insights.

The library is interactive, however, not only in the traditional sense of human-computer interaction, but also because it supports interaction among students, studio teachers and other architects in multiple ways. First, it gives students access to the work - and thus design knowledge - of architects outside the studio. Second, it acts as a collective external memory (Wegner 1987) for the students and studio teachers in the studio, enabling them to share knowledge, expertise and insights. Finally, it has the potential to increase the frequency and quality of the dialogue among students as well as between students and studio teachers. Newly added cases or indices, for example, may act as points of departure for discussion by highlighting specific aspects of the assignment not initially shared (Press 1998).

Apart from interaction, the tool can also be ascribed a certain action in the sense that it actively develops the user's design knowledge by stimulating him to learn from previous projects. When adding a new case to the library, for example, the user is responsible for representing and labelling the project in such a way that important aspects are legible and easily accessible (Äkin et al. 1997). This forces him to view the project from different perspectives and to answer questions like 'what does this project tell me?', 'in what circumstances might it be a relevant example?' and 'where does it fit in relation to the other projects?', questions that enhance the student's ability to understand and remember the project (Schank & Cleary 1995). In this way, the tool promotes the kind of thinking that helps to better learn from existing designs. Using the library in the studio in addition ensures that design knowledge is gained in the same context as it will be used. In general, students very rarely bring knowledge acquired in theoretical courses to the studio (Marda 1997). The reason is that they have not mentally encoded the material in terms of issues they face when designing. Because they have not thought about how it helps to solve problems at stake during design, the knowledge is difficult to access when they do face such a problem (Schank & Cleary 1995). In the studio, on the other hand, the project in which students are involved provides a framework on which students can hang newly acquired knowledge. Thus, the project does not only serve as a motivator - it stimulates

students to learn because they are eager to design a good project - but also as a guiding context to integrate what they learn.

2.3 **Multimedia**

A third way in which the case library differs from the reader has to do with the types of information provided. The pages in the reader only allow for (copies of) text, photos and drawings. The pages of the case library, on the other hand, are quasi unrestricted as to the information types they support. The essential difference is that they are written in hyper- in stead of traditional text, which allows us to integrate a whole variety of media. In addition to text, images and graphics, design cases can now be represented by 3D-models, computer animation, sound and video.

The advantages of this multimedia approach are manifold. Compared to written data, the visual and spatial representation of designs better fits the architect's way of thinking. Essentially, a design comes into being through manipulation of non-verbal information: the designer knows, thinks and works in a visual way. Furthermore, the combination of several modes of representation provides students with a rich learning experience (Vora & Helander 1997), helping them to better understand a design. Finally, hypertext allows us to link the case library to external information resources, which considerably enlarges the scope of its content.

3 IMPLEMENTATION

Within the scope of a graduate's thesis (Segers 1998), we are developing a working prototype of an interactive case library to explore the ideas presented in the previous section. In order to scale down the problem, we decided to build a case library for one specific design assignment. The honour goes to the design of a single-family dwelling on a sloping site, a compulsory project for the architecture students of the 2nd year at our department. However, this assignment should be seen as nothing more than a test-case. With an eye on a wide applicability, the library should be easily extendible to other building types and thus not tailored specifically for single-family dwellings on a sloping site.

The prototype library consists of three major components: 1. a collection of cases - the actual content of the library; 2. an underlying database that structures the library; and 3. an interface allowing to consult and modify the library.

3.1 Cases

To initialise the library, we collected cases from several sources. The selection was based largely on the current reader and consulted with the studio teacher in charge of the assignment. Cases in the library are entire building designs and can be represented by several media, such as text, images, graphics, 3D-models, video and sound. For each case, all information available in the library is collected in a central catalogue page with links to the corresponding files (figure 1). Next to each item, additional information can be listed as to the type and source of the file, when and by whom the file was entered, etc.

3.2 Structure

The underlying database that structures the library, was created with Microsoft Access 97. For each case the database inventories the address of the corresponding catalogue page as well as a set of attributes that can serve as filter criteria during retrieval. Provisionally, these attributes are architect, author (i.e. the person who entered the case into the library), building name, concept, program, site, special characteristics, surface and year of construction. We deliberately use the term 'provisionally' because as soon as the library

Figure 1: **Catalogue Page of the Kaufmann House by Frank Lloyd Wright**
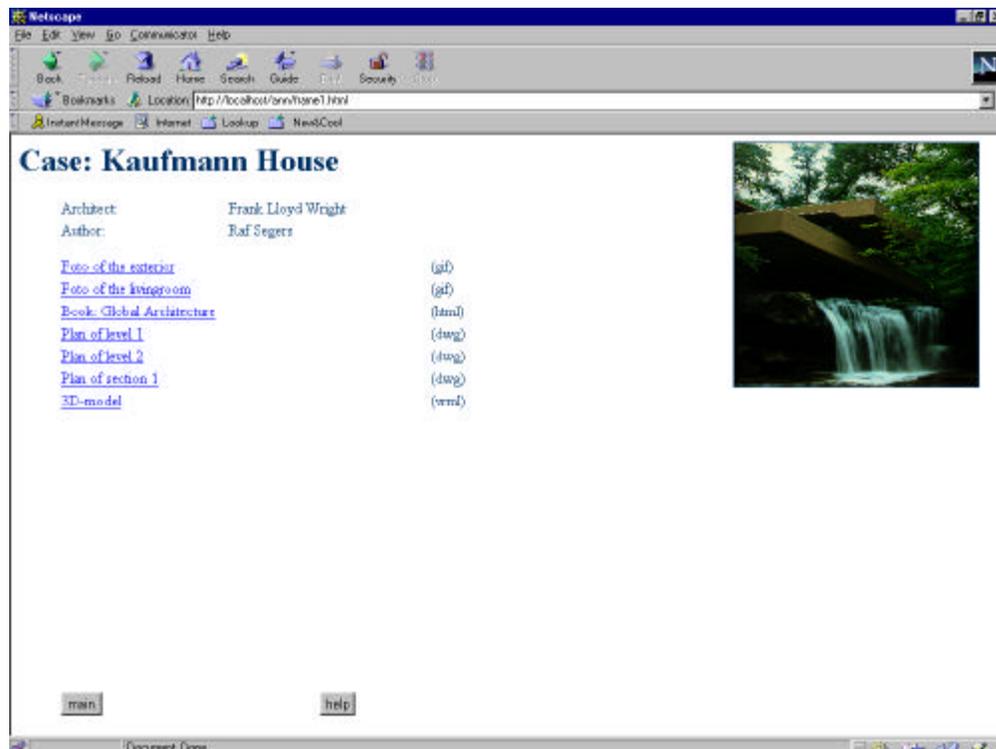
will be in use, the user can decide to delete attributes that turn out to be irrelevant or to add new ones. Only architect, advisor and building name are obligatory indices which taken together form a case's ID. Therefore they must be specified for each case in the library and cannot be deleted. The other labels are optional and only filled in when the attribute is considered relevant. This is certainly the case for the concept, since the library is primarily intended to support conceptual design. It seemed advisable, however, to index cases with other features too. Concepts in architectural design do not appear out of the blue, but often have to do with a particular position with regard to the program, site, etc. Moreover, the extra indices allow to select cases by other than conceptual criteria. When a project was built, for example, may be indicative of the style - be it Renaissance, Baroque, Post-, Neo- or other Modernism - or of the building technique used.

3.3 Interface

The interface needed to access the library is composed of different modules (figure 2). The user interacts with the library through a standard browser like for example Netscape. He can consult the library by simply specifying the selection criteria on the search page. The query may be very simple, for instance, the name of an architect. It is also possible to enter more complex queries as to find cases that match two or more criteria. Upon

Figure 2: **Chain of modules giving access to the library**
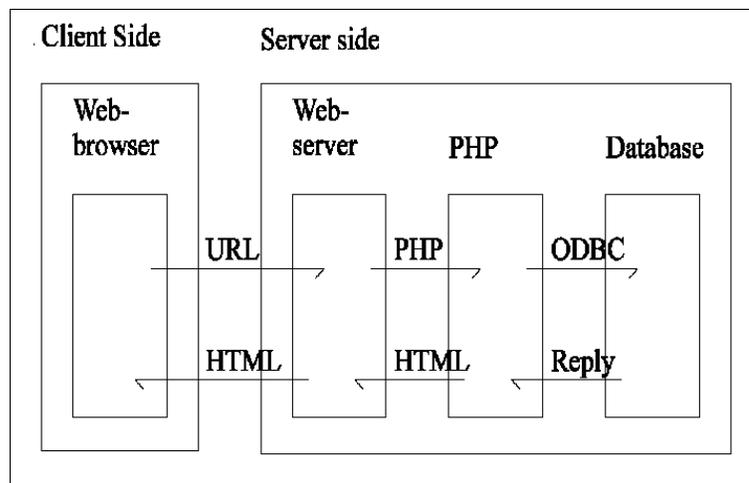
submission, the server transfers the query to a PHP-script which bridges the gap between server and database. By means of Open DataBase Connectivity (ODBC), this script can search the database for cases that match the query without having to start up Access. When the search is completed, the script transmits the catch via the server to the browser, which displays the results as a list of cases with links to the corresponding catalogue pages.

Apart from consulting the library, the interface also allows to transmit cases via the browser without having to change to another program. A user who wants to add a project, first sees a dialogue box requesting to fill in the case's ID - i.e. author, architect and building name - and to select the file(s) he wants to enter (figure 3). As soon as this mandatory information is submitted, a new dialogue box pops up with the request to specify one or more of the optional indices. In a similar way, the user can add supplementary files to cases already present in the library or label them with extra indices.

Figure 3: **Dialogue box for adding cases to the library**

4 SUMMARY AND FURTHER WORK

Recognition of the crucial role previous projects play in architectural design has inspired the development of an interactive case library supporting (student-)architects during design. We have outlined a conceptual model of the library by comparing its structure, (inter)action and types of information with the reader students receive today. Furthermore, we have implemented this model as a working prototype within the scope of
a graduate's thesis. The next step is now to deploy this prototype in the design studio, on the one hand to test its functional performance; on the other and more important hand to explore the underlying theoretical ideas. Awaiting this deployment, the case library already met with a mixed reception/was received with mixed feelings.

A prevalent prejudice is that its use in the design studio will considerably increase the danger of students blindly copying (parts of) previous projects, a phenomenon known as 'design fixation' (Christiaans & van Andel 1993). Yet, we strongly belief that specific designs have the potential to add to a student's pool of knowledge just as well as a lecture or a book. The present emphasis on originality and uniqueness wrongfully excludes this treasure of knowledge from informing design in the studio (Press 1998).

Another reaction we received is the suggestion to extend the retrieval mechanism of the library with a content search facility. The idea is to compare the search criteria specified by the user not only with the cases' indices in the database, but also with the text files they contain, which allows to find all documents which contain a given word. Since such search would indeed considerably increase the power of the tool, we hope to implement this extension in the near future.

A further step is to deploy the case library across multiple design studios within different classes, schools and even professional offices connected via the web so as to fully exploit its potential of knowledge exchange between (student-)architects in different contexts and at different levels of experience. However, we do not expect to undertake this step before the prototype has been tested and has proved to accomplish our goals within the walls of a single studio.

REFERENCES

Akin, Ö., Cumming, M., Shealey, M. et al. (1997) An Electronic design assistance tool for case-based representation of designs, *Automation in Construction* 6, pp. 265-274.

Christiaans, H. and van Andel, J. (1993) The effects of examples on the use of knowledge in a student design activity: the case of the 'flying Dutchman', *Design Studies* 14(1), pp. 58-74.

Dave, B., Schmitt, G., Faltings, B. et al. (1994) Case-based design in architecture, in Gero, J.S. and F. Sudweeks (eds.) *Artificial Intelligence in Design '94*. Kluwer Academic, Dordrecht, pp. 145-162.

Flemming, U., Coyne, R. and Snyder, J. (1994) Case-based design in the SEED system, in Khozeimeh, K. (ed.) *Computing in Civil Engineering, Volume 1, Proceedings of the First Congress held in conjunction with the A/E/C Systems `94,* Washington, DC, June 20-22, 1994. American Society of Civil Engineers, NY, pp. 446-453.

Heylighen, A. (1996) Case-based Reasoning in Architectural Design, graduate's thesis, Department of Architecture, Urban Design and Planning, K.U.Leuven, Leuven.

Heylighen, A. (1997) In Case of Architectural Design, in Filer, N. and Watson, I. (eds.) *UKCBR3, Third UK Case-Based Reasoning Workshop Proceedings*, Manchester, UK, September 9, 1997, 10 pp.

Kolodner, J.L. (1993) *Case-based Reasoning*. Morgan Kaufmann Publishers, San Mateo.

Marda, N. (1997) Visual Design Thinking, *STOA - Architectural Review of EAAE* 2, pp. 42-53.

Neuckermans, H. (1994) Ontwerpmethodiek, lecture notes, Department of Architecture, Urban Design and Planning, K.U.Leuven, Leuven.

Oxman, R. and Oxman, R. (1993) PRECEDENTS: Memory Structure in Design Case Libraries, *CAAD Futures '93, Proceedings of the 5th International Conference on Computer-Aided Architectural Design Futures*, Pittsburgh (PA), USA, July 7-10, 1993, pp. 273-287.

Press, J. (1998) Soul searching: reflections from the ivory tower, *Journal of Architectural Education* (submitted).

Schank, R. and Cleary, C. (1995) *Engines for Education*. Lawrence Erlbaum, Hillsdale (NJ).

Schmidt-Belz, B. and Hovestadt, L. (1996) Scenario of an integrated design support for architects, *Design Studies* 17, pp. 489-509.

Segers, R. (1998) Prototype van een interactieve case base voor architectuur - geïllustreerd met woningen op helling, graduate's thesis, Department of Architecture, Urban Design and Planning, K.U.Leuven, Leuven.

Smith, I., Stalker, R. and Lottaz, C. (1996) Creating Design Objects from Cases for Interactive Spatial Composition, in Gero, J.S. and Sudweeks F.(eds.), *Artificial Intelligence in Design'96*. Kluwer Academic, Dordrecht, pp. 97-116.

Vora P.R. and Helander M.G. (1997) Hypertext and its Implications for the Internet, in Helander M., Landauer T.K. and Prabhu P.(eds.), *Handbook of Human-Computer Interaction*. Elsevier Science B.V., pp. 878-914.

Wegner, D.M. (1987) Transactive Memory: A Contemporary Analysis of the Group Mind, in Mullen B. and Goethals G.R. (eds.), *Theories of Group Behavior*. Springer Verlag, London, pp. 185-208.