Design Analysis Network

An educational environment for architectural analysis

Bige Tunçer, Sevil Sariyildiz
Design Informatics, Faculty of Architecture, Delft University of Technology
http://toi.bk.tudelft.nl/

Design Analysis Network (DAN) is a web-based environment for the construction and presentation of a body of architectural analyses in the context of a design studio. We use DAN in order to achieve an extensible and cooperative library of architectural design analyses; searchable by content, and instructional for coming generations of students. DAN also acts as a presentation environment for students, where they can present their analyses to their design instructors. DAN has been used in two iterations of instruction in the second year design studio at the Faculty of Architecture.
After its use, we carried out an extensive evaluation of the use of DAN, its usefulness and how it fits into the educational process, in a laboratory environment. The evaluation results provided valuable insights. In this paper, we describe the DAN environment and its tools, and we discuss its use in the design studio. We also describe its evaluation process and results, the analysis of these results and their conclusion. We conclude with recommendations for improvement to the application and its implementation within the design studio.

Keywords: *Architectural analysis; conceptual design; extensible library; design studio education; precedent-based learning.*

Introduction

Design Analysis Network (DAN) is a web-based environment for the construction and presentation of a body of architectural analyses in the context of a design studio. In architectural education, complete and thorough analyses of architectural bodies and objects are indispensable. These analyses cover many different aspects of the subject, e.g., physical and contextual attributes as well as geometric, functional, typological and organizational relations.

The main purpose of design precedent analyses as part of architectural education is to teach students design principles using existing examples. This way of learning has been referred to as *precedent-based learning*, and is a common method used in the architectural education system (Akin, 2002; Lawson, 2004; Schön, 1985). Precedent-based learning aims at helping students learn to understand design principles, formulate, isolate and define design problems, and to use this knowledge in their design. A study of such precedents can yield, among others, heuristics used by the designer, design principles for various purposes and situations, and prototypes from building

typologies. Subsequently, precedent-based design is the "selection of relevant ideas from prior designs in current design situations" (Oxman, 1994). Precedents contain design knowledge that can be accessed and reused in the context of the design problem at hand. Precedents provide both conceptual and physical knowledge to designers (Akin, 2002). However, one uses already existing knowledge in order to reason with precedents (Tzonis & White, 1994).

It is easier for experienced architects to deduce knowledge from precedents and to use this knowledge in designing because of their experience and prior knowledge. When experienced designers view a precedent document, they can quickly extract knowledge from the precedent by perceptually recognizing the schemata that conceptually organizes the precedent rather than analytically studying the design (Lawson, 2004). For design students or novice designers, the situation is different. Novice designers need to be educated to understand and work with 'guiding principles' (Lawson, 1990). For example, the main guiding principle in Calatrava's designs is usually movement (Tzonis & Lefaivre, 1995). Other guiding principles could be geometry, light, or movements patterns in space. Expert designers have established guiding principles. By studying such designs, these guiding principles can be detected, and furthermore, sometimes, the precedents that have inspired these can be detected. The detected principles are physical and/or conceptual.

In support of educating designers, a collection of relevant design precedents and an organization of the structure of the knowledge they contain is useful in the design education context, as well as in offices for beginner designers to learn from experienced designers. By guiding an analysis in an analysis environment and integrating the analysis results into a common library, students can draw upon others' results for comparisons and relationships between different aspects or buildings.

There are a number of systems developed for computationally supporting conceptual design using precedents. Some of these are merely electronic catalogues. Others are also targeted at supporting cognitive processes of designers at the early stages of design, as well as providing organized precedent libraries (Akin et al., 1997; Heylighen & Neuckermans, 2000; Madrazo & Weder, 2001; Muller and Pasman, 1996). Some target the cataloging, adaptation and reuse of knowledge embedded in 'cases' (Flemming, et al., 1997; Oxman & Oxman, 1993).

DAN acts as an analysis environment that integrates the guiding principles, both physical and conceptual design concepts, and design instruments as members of the organizational structure for the organization of precedents. Using this structure, students are required to make claims on the actions they perform during analysis. This ensures that students produce more than marked plans. In addition to being an analysis environment, DAN makes precedent documentation available on the web within the same environment that the students use for the presentation of their own analysis results. The result is a common library such that students, in later design activities, can draw upon other students' results for comparisons and relationships between different aspects or buildings. Analysis results can be searched and browsed by content. This structure allows associative browsing, which acts as a cognitive support mechanism in conceptual design (Lin, 1997). DAN also acts as a presentation environment for students, where they can present their analyses to their design instructors.

In this paper, we shortly describe the DAN environment and its tools and we discuss its use in the design studio. Next, we describe its evaluation process and results, the analysis of these results and their conclusion. We conclude with recommendations for improvement to the application and its implementation within the design studio.

DAN in the design studio

DAN has been used in two iterations of instruction in the fourth semester (second year) design studio at the Faculty of Architecture, Delft University of Tech-

nology. The fourth semester design studio is offered to about 260 students per year. We have used DAN in Fall 2002 with 86 students and in Fall 2003 with 108 students. In this paper, we describe the second run of the course. The sessions took place in a computer lab environment. The DAN assignment was completed in one workshop of 3.5 hours. The workshop started with an explanation session of about half an hour. Then the students completed the assignment, asking the teachers questions if necessary. Students teamed up in groups of two to complete this assignment.

The central design theme of the fourth semester design studio is a "small public building". In the first time use of DAN, the project was a small theater, and the second time, a small museum. The students are given a relatively complex functional program and are requested to design and work out the materialization of this building. The students begin the studio by analyzing selected historical and contemporary precedents of the relevant building type with respect to various criteria (composition, program, construction, context, type, etc) and from structural, formal, and functional points of view. The assignment given to the students was to do two analyses of a selected building from the initial repository of buildings according to two criteria, to write a short concept document for their own design, and then to do a search in the database in order to find analysis examples related to their own design concept. Many students did not do the second and third step, because they were running late in their studio project and they did not have a concept yet, although according to the schedule, this should have been possible.

In this design studio, the method instructors use for the analysis exercise is that students gather documentation about a specific building type, they investigate the goals of the architect, the instruments the architect uses, and they do a critique of how these instruments have succeeded to reach the original goal. However, students sometimes tend to draw mindlessly colored areas on plans, claiming that these are the result of an analysis, whereas these are the result of some mechanized analysis efforts. In such a case, students do not really gain the physical and conceptual knowledge residing in the design precedents. Ideally, students need to be aware of and think about every action they perform during an analysis. One way of ensuring this can be that they make claims on each step of the analysis, and also, provide explanations to the graphic notation they are using during analysis (Steenbergen et al., 2002).

In order to enforce this awareness, DAN has been integrated into an e-learning environment called InfoBase, developed at the Design Informatics Chair[1]. InfoBase utilizes a system of four quality dimensions (Groen et al, 1980; Kooistra, 2002) specifying constructive, relational, objective and subjective claims. These claims are represented as keywords. Applied to the context of architectural education, we want the student or future architect to learn to lay claims on data collections as designers. When students lay claims on a design, the unique combination of metadata from these four dimensions constitutes a 'KeySet' for this data (Stouffs et al., 2004).

The use of DAN

The students used the InfoBase DAN system for completing their assignment. There were a number of modules integrated into this system: the digital repository of precedent documentation, the DAN toolkit, and the browse and search interface for the collection of completed analyses.

The first step was the selection of a building to analyze from the collection presented in the repository. This repository offers an overview of documented precedents, organized according to name of building. This documentation contains drawings, photos, and texts. Students can also add new precedent buildings and new documents into the repository. The newly added material is available to all students. In this design studio, the process of documen-

[1] http://infobase.bk.tudelft.nl: Dec 2004; Stouffs et al., 2002

tation forms an integral part of the analysis process.

The analysis of the selected precedent building investigates various criteria, for instance, composition, program, construction and context. The analysis is carried out in close relation to the concepts described in the four dimensions of claims: the relational, constructive and objective claims are provided to the students; the subjective claims are freely defined by the students. The relational claims represent the guiding principles of buildings (e.g., constructional organization, flexibility in use, functional organization, light as design instrument, relation to surroundings, routing, and spatial organization). The constructive claims represent the instruments used by the architect to achieve the desired result (e.g., finishing, structural system, utility systems, organizational pattern, color, massing, material, enclosure system, proportion, rhythm, functional units, scale, symmetry, texture, transparency, construction process, and circulation system). The objective claims represent the type of the design document (e.g., elevation, axonometric view, diagram, section, and photograph). These are mainly used for determining the representational medium for expressing the ideas, and furthermore, to enhance the searching and retrieval mechanism that students use later during the assignment.

The analysis process starts with the students selecting an aspect that describes the purpose of the analysis. In this way, students select which aspect of the building they wish to analyze. This decision comes from studying the guiding principle or principles that played a role in the design of the selected building. For example, the movement route of the visitors has played an important role in the design of the Kunsthal in Rotterdam, designed by Rem Koolhaas. Students select a keyword from the list under the relational claims for this purpose. For example, choosing "routing" for Kunsthal – Rotterdam would be a good choice.

The process of selecting this keyword for the analysis to start with is done in the *DAN toolkit*. The students load one of the visual documents belonging to the selected building (most of the time a plan or section) as basis for their analysis into the DAN toolkit, and select it. The document being selected, students select at least one keyword from the relational, constructive, and objective dimensions. For example, a constructive and an objective claim for the Kunsthal – Rotterdam could be respectively "circulation system" and "axonometric view". Then, they type in a keyword as a subjective claim. This keyword expresses their opinion or subjective view about this aspect of the design. This set of four keywords forms a unique 'Keyset' for this analysis. A selection from the collective set of subjective claims created by the students is "practical, insightful, traditional, elaborate, far away, hidden, refreshing, contaminated, boxy, strange, floating, flat, postmodern, fantastic, calming, and intense".

Next in the analysis process, students start working out the analysis. This is usually done by drawing diagram-like notations on a plan for example to show the circulation scheme, or the functional zoning, or the level differences on the section, etc. Using the DAN toolkit, students can draw a number of markers on the base document. The toolkit offers the user the ability to draw section, view, colored areas and annotations. Students can select a color for these markers.

The markers have to be associated to at least one claim from each dimension. In addition to selecting a KeySet for each marker, students can relate a marker to other documents that reside in the repository. These documents are automatically loaded into the toolkit. This linking is done by selecting the marker, and clicking on one or more design document thumbnails on the right side of the interface. This makes these selected documents related. Considering that the result of this analysis is presented as a clickable image map with hyperlinks to all connected documents, one can create a sequence of images, a digital story, marking sections on images, linking them to other images, following a story (Figure 1).

In addition to the mandatory association of keywords and the possibility of associating other docu-

ments to markers, it is also mandatory to write a short annotation about each marker. This annotation is meant to clarify the purpose and meaning of the student's action, in order to allow for a self-explanatory analysis. In addition to the claims, the annotations enable the transfer of knowledge to other students and instructors when they retrieve the analysis from the repository. Students are also allowed to load an already worked out analysis, for instance in an image processing program, into the DAN toolkit as the basis image. They are, however, required to complete it with claims, annotations, and possibly references to other documents.

The result of placing the markers on the base image and all the associated actions is the generation of an image map from these. Such an image map can serve as an entry page to an analysis, or as a content map or index to a collection of related documents. When one moves the mouse pointer over a marker, a preview image of the associated claims and the related document and the annotation appears. Markers can be clicked on to browse to the respective document. The view in Figure 2 shows the analysis result in a way that can be presented to the design instructors. It numbers the markers, and it shows all the associated claims, to the main analysis and to the markers, and the associated documents for each marker.

The result of the various analysis results was a common collection that the students could later consult for support of their later design activities. This is a search and browse mechanism on the basis of the hierarchy of claims. The top section contains the claims and their dimensions. Users can select one or more keywords from each dimension, and the result set is displayed below. The upper section of the result set displays the results where the terms appear in the main analysis. The lower section displays the results where the search terms appear in a marker in the analysis. This way, the content of the analysis becomes retrievable. Students, but also instructors and other interested parties can search and browse the results.

The next step in the students' assignment was

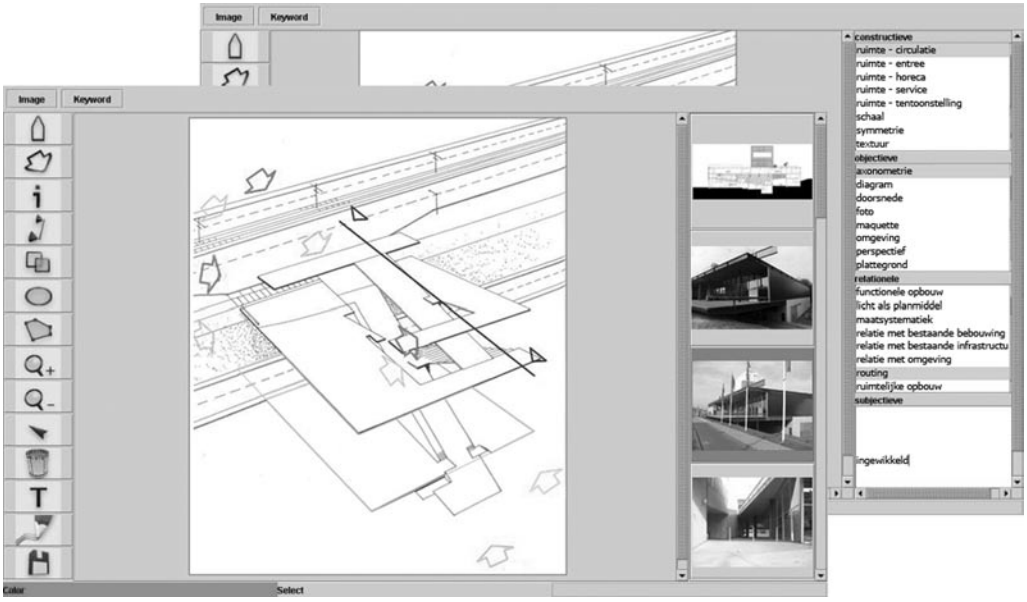

Figure 1
Snapshot of the application that serves to generate image maps using various markers that are related to other documents or claims.

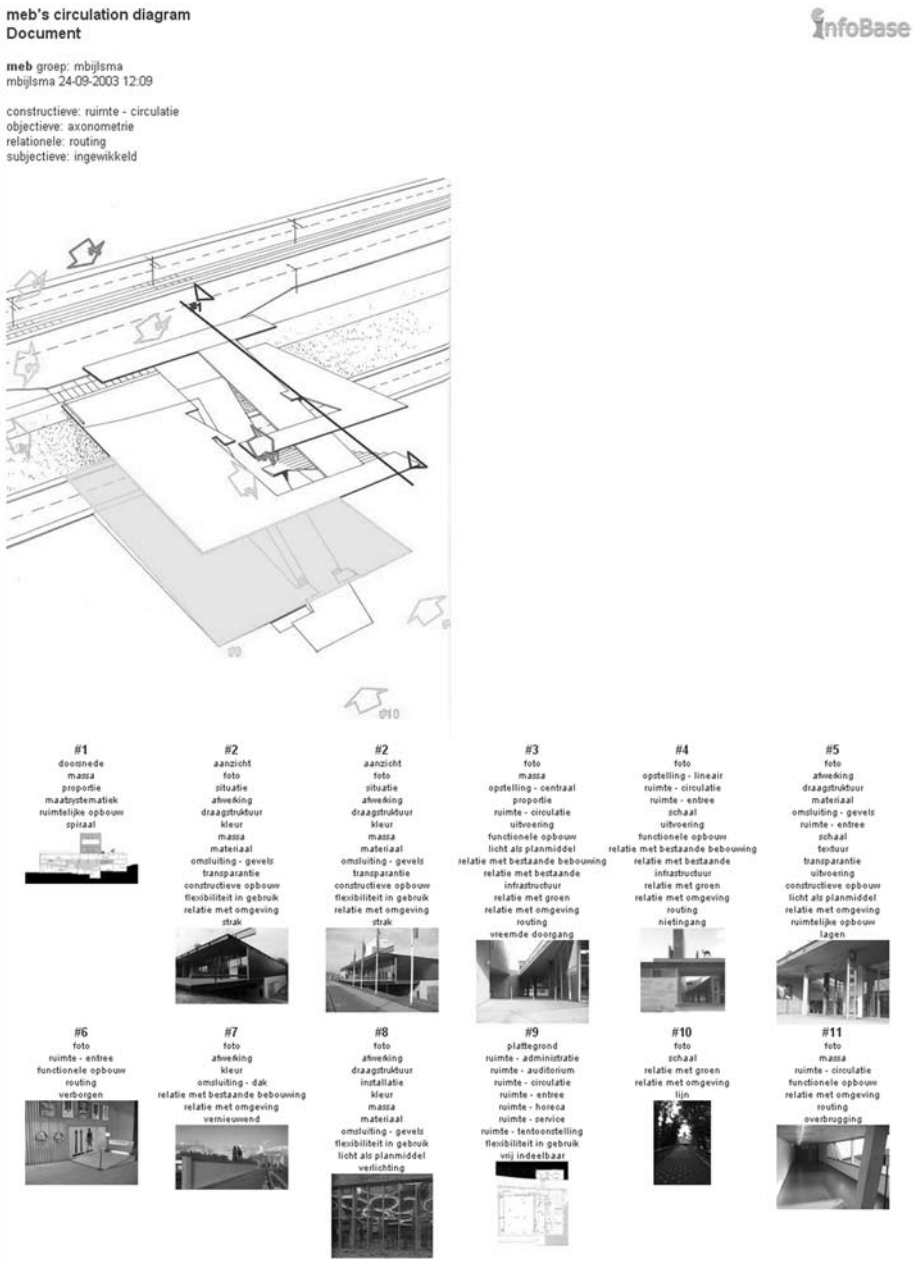

Figure 2
Resulting image map with various markers, composed in a printable view with all the related documents and their claims.

to search in the database for examples that support their own design concept for a museum. This support could express itself in a way that strengthens their concept by verifying that it works through precedent knowledge, or by selecting another concept and showing that something else needs to be done in the context, and the selected precedent fosters that.

The evaluation of DAN

In spite of some very promising results and the high enthusiasm of the design instructors, there were a number of problems with the use of DAN in the 4th semester design studio. From the use of DAN, it became apparent that students had difficulty to appreciate the added value of using such a tool in their analysis process. It was, however, difficult to determine what precisely the source of these problems was: the shortcomings in the presentation of information and the interface; the functionality of the tool; or the embedding in the education. The evaluation was therefore aimed at investigating the problems with each of these fields: interface design, functionality, embedding in education. We did an extensive evaluation of the use of DAN in a laboratory environment: the Laboratory for Work and Interaction Technology (WIT-lab), at the Faculty of Technology, Policy and Management of the Delft University of Technology. The evaluation consisted of 5 sessions of 2.5 hours each on an individual basis with students who had already done the DAN exercise.

Setup of the evaluation

During the evaluation, the course instructor (also developer of DAN) and an individual student who had already done the DAN exercise sat in a room with a computer that ran the software. In the control room, the test leader, another project member, and one or two of the other design instructors followed and commented on the activities that went on in the test room. The events in the test room, as well as the comments in the control room were logged in a logbook, and coupled with the video recording of the events in the test room. Each session advanced as follows: the student showed the instructor how she had performed the analysis assignment. The instructor asked for clarification from the student where necessary, or helped with the solution of problems related to the use of the interface. Afterwards the instructor explained to the student what the vision of the DAN project group was on the role of the DAN tool should be during the performance of the assignment. The student searched the analysis results for a meaningful example in order to illustrate the explanation of the instructor. This example was formulated by the student herself; it was based on her own design ideas. Next, the student performed the assignment one more time using the tool, this time according to the instructor's explanation.

At the end of each individual session the activities and comments were discussed with the observers and the instructor from the test room, on the basis of the logbook, and supported by the video recordings. In these discussions, the goal was to define problems based on the logbook or hinted by the logbook in the areas of ease of use and learning curve of the tool, the added value of using the tool, and the added value and the use of the embedding of DAN in education. The comments that came up in the discussions were categorized and summarized.

Summary of findings

An important observation was that DAN gives too few examples to students (and instructors) that illustrate the added value, and does not provide enough explanation about how students can work with the tool. Furthermore, students have no clear idea how to analyze a building, neither how such a process can go. Moreover not all the instructors have the same opinion about how to do an analysis. When students see how the tool can be used (during the evaluation session) their enthusiasm appeared to be great (with one exception).

The most important conclusion is that the analysis process must be defined explicitly and clearly and

this process must be integrated in the tool. Thus, the tool must assist the users in acquiring a method to do analysis work. Another necessary adjustment is that a number of analysis examples must be provided to the users that illustrate the usefulness and use of concepts. The use of DAN must be truly integrated into the design process, and not be seen by students as "doing double work". Finally, a number of small but disturbing usability problems were detected that hindered the students in their assignment.

Conclusions and Future Work

In spite of the technical and usability related shortcomings, DAN, as an application and as a process has been successful in the design studio education in the Faculty of Architecture, Delft University of Technology. Because of the large number of students and design instructors, a predefined structure of an analysis process and design concepts helps the coordination between design instructors themselves and helps to maintain a uniform instruction method. Furthermore, because of its web-based nature, it is universally reachable. Most importantly, it has been evaluated as allowing the students to learn more from an analysis.

In accordance with the findings and suggestions above in relation to usability related and technical aspects of DAN in the context of the 4th semester design studio application, we have worked out requirements for a redevelopment plan for the software. A number of meetings were held with the project coordinator of the design studio and the other design instructors and many requirements for this plan have been derived from these meetings in addition to the points that were derived from the evaluation report. This plan includes requirements for functionality as well as process.

The goal is the development of a digital analysis tool that supports the building of an extensible and searchable digital analysis library. In order to be successful, the use of this tool must be integrated in the design process in the design studio, and the design instructors must also actively use the tool. In this context the analysis process that is in use in the studio must be integrated in the tool. The improved DAN tool will be used for the performance as well the viewing of the analyses. In the development, an attractive, intuitive and user friendly interface will be a top priority.

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