Supporting Case-Study Use in Design Education:
A Computational Case-Based Design Aid for Architecture

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Abstract

Cases play a central role in architectural design education. Many architectural journals, books and magazines are based on case studies of buildings, and instructors commonly use cases in lectures and studio teaching. These cases, which are often descriptions of the form, materials and design strategies of significant buildings, are used by students for a variety of purposes. They help elaborate and refine stated problems, suggest and refine design solutions, help evaluate a completed design and suggest possible alternative solutions. However, appropriate cases are scattered across the print literature and may be difficult to find.

Perhaps more important, the ways in which most current cases are written and made accessible to students does not exploit their full potential as pedagogical tools. In this paper we describe "Archie" a "case-based design aid" (CBDA) that provides architecture students rapid and flexible access to evaluated multi-media design cases. A CBDA is a computational aid that provides novice and experienced designers access to cases that they can then adapt to solve their current design problem. Based on the theory and technology of case-based reasoning, a CBDA uses the computer to store and access cases and allows human designers to do their own adaptation.

Archie is aimed at aiding teaching of conceptual design. It is intended to help students: 1) understand the intentions of the range of stakeholders who have an impact on a building project, such as designers, users, clients, and builders; 2) develop more explicit statements of goals and criteria for success of their designs; 3) make links between general goals and specific design solutions; 4) link written statements of goals and needs to graphic representations; 5) keep design problems open long enough to allow students to explore an appropriately wide range of possible solutions.

Archie: Content and Browsing

Archie is a computer tool aimed at supporting teaching of conceptual design and at aiding design. It
is written in Common Lisp on Macintosh, and is based on a theory and technology called "case-based reasoning" that suggests that much effective problem-solving is based on retrieving and adapting appropriate specific past experiences (Kolodner, 1991, 1993). Archie provides students access to evaluated cases based on post-occupancy evaluations of occupied buildings (Friedmann, Zimring & Zube, 1978). Cases in Archie are structured as descriptions, problems, design responses and stories.

- **Descriptions** are the most common architectural presentation formats in architectural books and magazines. In Archie, these are available as building plans, sections, elevations, sketches and texts.

- **Problems** in Archie are dilemmas to be solved. We believe that it is important for students to understand that most design decisions attempt to resolve conflicting requirements. Problems in Archie are usually represented as two or more relatively general intentions, with an implementation that fails to solve both intentions. The program then allows students to explore responses that will resolve both intentions.

- **Design responses** are general strategies a designer might consider for reconciling the intentions.

- **Stories** are brief descriptions of how the problem or solution has played out in a specific building.

Graphic material (illustrated/annotated plans, photographs, and drawings, and even quick time animation sequences when applicable) are associated with each text item. Each problem and story is indexed using a set of features (index terms, issues, systems, etc.) developed specially for the Archie case library. Related items are also cross-linked for browsing.

In developing Archie, we observed students and professional designers doing design and discussed pedagogical strategies and problems with design instructors. We have attempted to provide a high degree of flexibility for users of the system to access information to fit their personal styles and specific tasks. However, we also provide "scaffolding" by linking related items. Users can find an appropriate case in two major ways: index-based browsing and hypertext-based browsing.

- Using the **indexing system**, a user can search for a given artifact (building or part of building) or search for a problem, story, or response. These indices reflect characteristics of the design such as size, architect, location, or use-type of the building, as well as the content and pedagogical point of the problem or story, such as stakeholder type or mechanical system. For instance, if a student knows she will soon be doing a studio problem involving a child-oriented public library, she can search for all stories or problems related to children in libraries. In browsing these stories she soon finds some important dilemmas that need to be resolved in her design. For instance, adults who bring their children to the library often like to maintain visual supervision over their offspring, but if the children’s area opens directly onto the adult reading room, noise from the children may disturb other readers. Later in her design process, she may search for information about a specific feature such as circulation desks, or may search for descriptions of a specific library that she was interested in learning about.

- With **hyper-text links**, the user can move directly from design descriptions to stories, from stories to problems, and between problems and responses. For instance, the user described above, having found the problem of children’s noise disturbing adult readers, can move directly to descriptions of two or more response strategies (such as using separate rooms,
acoustic treatments, or glass walls) and how these responses have worked in stories of actual buildings. These stories are linked to design representations such as floorplans.

A designer’s search may also take her in unexpected directions. For example, in Figure 1, below, a student who is interested in learning about problems related to bringing natural light into the interiors of library buildings may encounter stories about courthouses that have grappled with the same problem. The system then allows her to copy the appropriate indices for the specific story to allow further search, as is illustrated in the upper part of the figure. Or, she can use the hypertext links between story and design to explore a specific courthouse case that in fact has many problems shared with libraries, such as maintaining security. This is shown in Figure 2.

Figure 1: In Archie, problems are linked to multiple responses and stories to help students understand that successful design solutions resolve conflicting intentions, and that problems typically have several potential strategies for resolving them. Text is always accompanied by graphics.

Figure 2: Stories are linked to a representation of the design such as a floorplan or elevation to allow students to put
Discussion and Future Research

We are currently focusing on libraries, courthouses, and tall buildings as initial building types. Archie includes a range of intentions, including social and organizational issues, structural and technical issues, and handicapped access. We have conducted several initial usability tests with undergraduate and graduate architecture students, where students used the system as part of a studio exercise to design a community library. Archie will be used by 39 graduate architecture students as part of their studio learning process in February, 1995. We believe that this approach of structuring cases as story-telling presentations provides a useful alternative in design education to other paper-based case formats.

Our prototype is simple, but it helps designers understand what intentions are involved in designing a building and how specific case examples support those intentions. Different stakeholders thus have a way to express their concerns in absentia and designers learn perspectives of other people from the previous cases. We believe Archie shows an appropriate way to integrate case based
reasoning into learning environments for conceptual design. In structuring our evaluated stories into our Case-Based Design Aid, we feel we have overcome one of the features of library article search that architects find most limiting: it is difficult to find examples that directly point to the problem at hand. In addition to illustrating this approach with a case base about building design, we have also developed Midas, a case based tool kit for aircraft system design in collaboration with Lockheed (Domeshek, Herndon, Bennett, & Kolodner, 1994).

This project has allowed us to focus on how cases, and particularly POE information, can be structured and presented in interesting and engaging ways. We also intend to continue expanding the types of data the program can manage. For example, we now have the ability not only to display text, but also color images, and QuickTime animations.

We are also dealing with a larger range of pedagogical goals. Most real-world design problems are solved collaboratively by a team, yet architecture students seldom get experience or training at collaboration. As a result, we are linking Design-MUSE, the CBDA shell we used to create Archie, with a collaboration-support system called CaMILE, that allows teams to carry on structured processes of collaborative design (Guzdial, Rappin, & Carlson, 1994).

We also believe that users will get the most out of a Case-Based Design Aid when this rich information resource can be directly tied to the design environment in which they are working. We are working with Mark Gross to link Archie to a freehand sketching environment (Gross, Zimring & Do, 1994). For instance, designers will be able to find relevant stories in the case base, copy their diagrams into the sketching program, and enhance, embellish, and develop the diagrams into more rigorous drawings. In future versions, Archie could watch in the background and take opportunities to display examples of relevant designs. As part of a smoother transition between the stages of conceptual diagram and design development, we would like to program the sketching environment to maintain the spatial relations in a diagram — such as adjacency, proximity, relative size, and alignment constraints — as the user moves from bubble diagrams to more precise design representations.

The development of the Archie system using POE stories puts us in a position to confront more directly the problems of scaling up and of generalizing issues. Putting together a well stocked CBDA is like authoring a major digital, interactive, multi-media encyclopedia. We would like to make our system easier for all potential users to contribute, lessen administrative and maintenance burden, and improve handling ability for large data sets. It has proven very time-consuming to gather and write case material, and we hope to speed this up with clearer guidelines for writing items, and with automated tools for indexing.

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