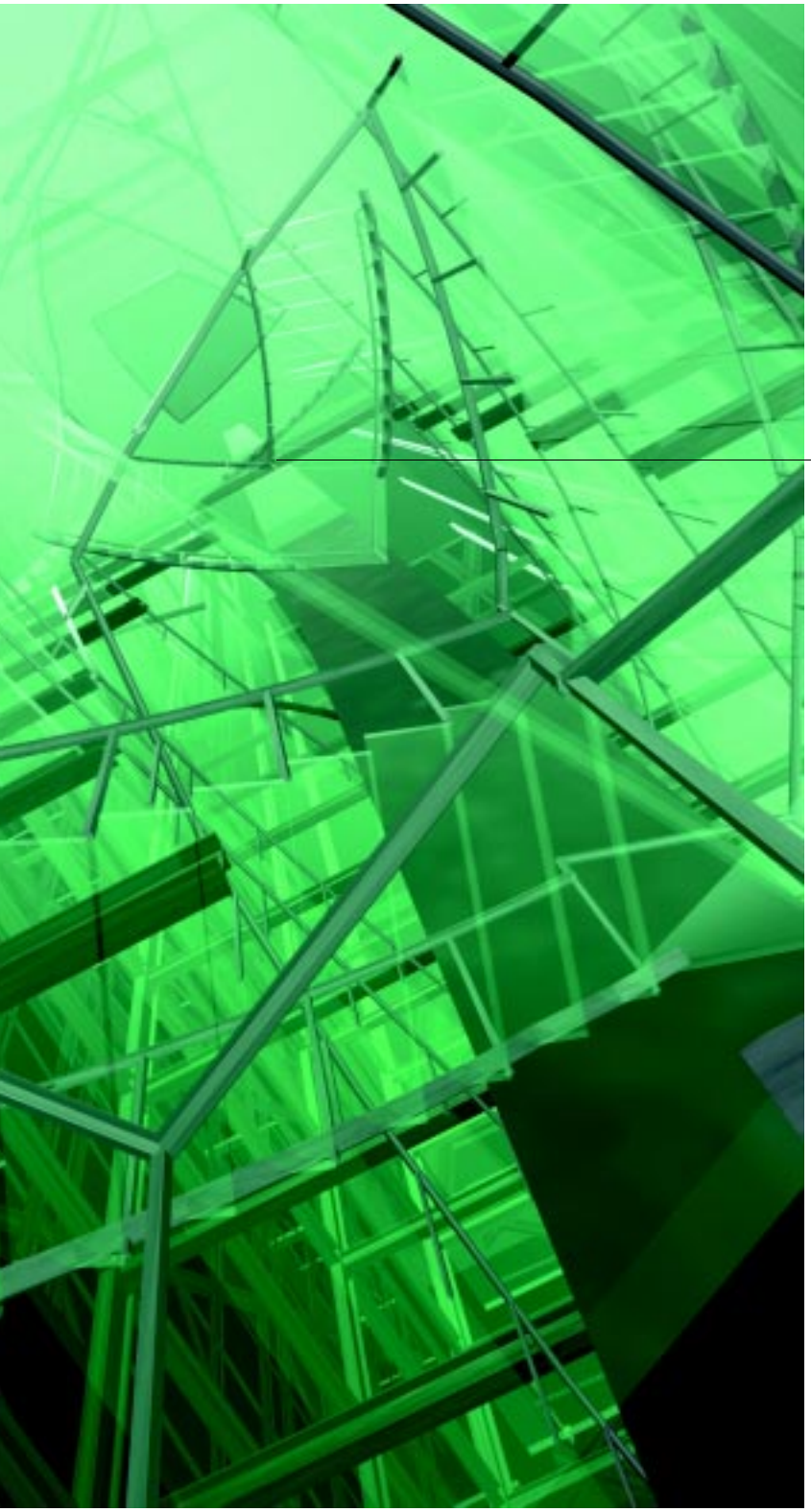

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Cultivating Design Competence: Online Support for Beginning Design Studio

A primary lesson of a beginning design studio is the development of a fundamental design competence. This entails acquiring skills of integration, projection, exploration, as well as critical thinking–forming the basis of thinking "like a designer."

Plaguing the beginning architectural design student as she develops this competence are three typical problems: a lagging visual intelligence, a linking of originality with creativity, and the belief that design is an act of an individual author instead of a collaborative activity.

We believe that computation support for design learning has particular attributes for helping students overcome these problems. These attributes include its inherent qualities for visualization, for explicitness, and for sharing. This paper describes five interactive multi-media exercises exploiting these attributes which were developed to support a beginning design studio. The paper also reports how they have been integrated into the course curriculum.

Le développement des compétences en design: Support on-line pour le studio de design élémentaire

Une des premières leçons lors du studio de design est le développement d'une compétence fondamentale en conception. Ceci implique l'acquisition des habiletés d'intégration, de projection, d'exploration ainsi que la pensée critique—antérieurement les bases de la façon de penser nommée 'comme un concepteur'.

Il y a trois problèmes fondamentaux qui pèsent sur l'étudiant débutant en architecture lors du développement cette compétence: une intelligence visuelle insuffisante, le fait de lier l'originalité à la créativité, et la croyance que le processus de conception est une activité individuelle, plutôt que collaborative.

Nous sommes de l'avis que le soutien en informatique lors de l'apprentissage de la conception architecturale posséde des attributs bien particuliers pour aider les étudiants à surmonter ces difficultés. Ces attributs comprennent des qualités inhérentes pour la visualisation, pour être explicite, et pour le partage. Ce papier décrit cinq exercices de médias interactifs qui exploitent ces attributs, et qui ont été développés pour supporter un studio de design élémentaire. Il présente aussi un reportage sur la façon dont ces exercices ont été intégrés dans le curriculum du cours.

introduction

One of requirements of a beginning design subject, regardless of the practice domain involved, is the development of fundamental skills. These skills form a primary design competence and can be characterized by modes of working which include integration, exploration, projection, as well as thinking critically. Beginning design students typically run into three problems that inhibit their acquisition of this competence. First, their visual intelligence–the ability to discern form and think in a visual mode–lags behind the development of their verbal skills. Second, they carry with them preconceptions that design is the business of coming up with something "never before seen" and associate originality with creativity. Third, they often conceive of architectural practice as that of an individual author instead of a collaborative activity (Pye 1964).

The beginning design studio that introduces students to this fundamental design competence is comprised of lectures as well as studio work. The twice weekly lectures outline a set of issues and methods which are in turn explored through a series of structured design exercises in the studio. Representation skills, such as drawing and modeling, are introduced as part of the design exercises. The studio is structured in three modules: the first looking at dimensions of the built-environment, the second at issues of form and use, and the last at issues of making. Within each of these modules, design teaching is seen of a process that entails learning how to see, learning how to explore problems, and learning how to argue for values.

This paper describes the development of multimedia course materials for use in the first year architectural studio and the integration of these exercises into the studio curriculum. The role of computational support in this context is to reinforce the connection between the general information in the lectures with the individual explorations in the studio.

properties of computational support

Computer-based teaching materials have compelling attributes that are particularly helpful in directing students to see, to explore, and to argue. These attributes include the media's inherent qualities for *visualization*, for *explicitness*, and for *sharing*.

Visualization is something designers typically do very well — in fact, theoretical information in architectural design is often conveyed through diagrams, drawings, or models. Historically, the teaching of design has been dependent on the use of diagrams to make explicit particular generative or "form making" concepts. In "Elements et theories de l'architecture," the 1894 treatise by the Beaux-Arts theory teacher, Julien Guadet, diagrams are used extensively to help formalize discipline knowledge that makes up part of the basic competence of the architect (Guadet 1894). This tradition continues today, though less explicitly. The design critic typically spends time sketching at the desk of a student, drawing in a manner that isolates and argues for a formal structure critical to the development of a design. In this manner knowledge about form is demonstrated and communicated (Fraiser 1994, Herbert 1993).

The knowledge contained in such diagrammatic representations is neither static nor a solution, rather it is dynamic and critical. It is *dynamic* in that it articulates morphological aspects of the formal structure, where the designer, looking at a diagram, sees not a template but a means to competently explore the problem. This dynamic nature of the form allows the designer to look at places as well as one's own drawing and imagine what it might become–its potential (Robbins 1994). Diagrams in design drawing are *critical* in that they argue for the significance of certain relationships over others and allow the designer to structure decisions in the development of a design. The ability to perceive form in this manner is crucial to developing a visual intelligence in design (Crowe 1995).

This visual intelligence is typically taught by making drawings and diagrams of existing places and by requiring alternatives or variations of designs in the studio. A new view of this knowledge is offered by the computer through the ability to build simulations and animate drawings, which aids in learning the dynamic nature of form and allows the student see the ways and means to explore a problem.

Explicitness is a requirement for working with computers. In building a simulation or structuring information, one is asked to be explicit about what is known, be it a process, a category, or a geometry. While this may not be particularly interesting in some fields where a knowledge base is agreed upon and articulated, in environmental design–where the discipline is recognized, but poorly articulated, and where design often proceeds along intuitive lines not dependent or derived from explicit knowledge–the demand for explicitness is significant.

Articulating the discipline of design, its knowledge base, offers the student an explicit view of the competence required in the practice. In lieu of an articulated discipline, the student often sees performance criteria as either tied to "self-expression" or to the approval of the "master," who in the master / apprentice role "is in possession of great secrets" (Habraken 1980). Explicitness promotes a discourse about the ideas, methods, and values with which that design and opens up paths to learning for the design student. In this course the lectures outline a view of the discipline which establishes the general concepts that individual designs explore. In the demands and excitement of the studio explorations, the general discourse is often lost. By making the lessons of the lectures available in the form of diagrams, simulations, and case studies, the connection between the students' own discoveries and the discipline is strengthened.

Sharing is a critical quality to promote in a design culture. Design practices are by nature social. Within a practice, a design is the result of the collaboration of groups of people; and within a culture, places are the result of interactions of many value systems and interests. Environmental design proceeds either informally, for example cultural sensibilities expressed in a traditional environment, or formally, as in the case of building codes (Habraken 1988). In both cases there is a shared basis of understanding about the built environment. Establishing ways of sharing for the design student promotes cooperative learning within the studio and helps to further discourse about the work. Such a culture promotes exchange among design students and prepares them for a practice that is able to engage a variety of value systems.

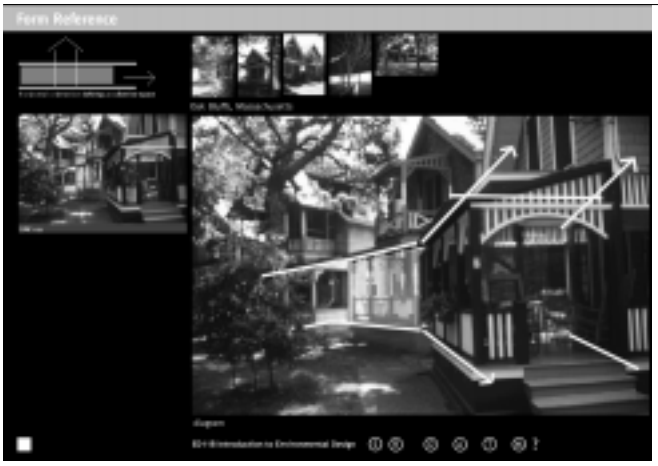

Figure 1. Form Module. Screen shot of reference window with diagramming.

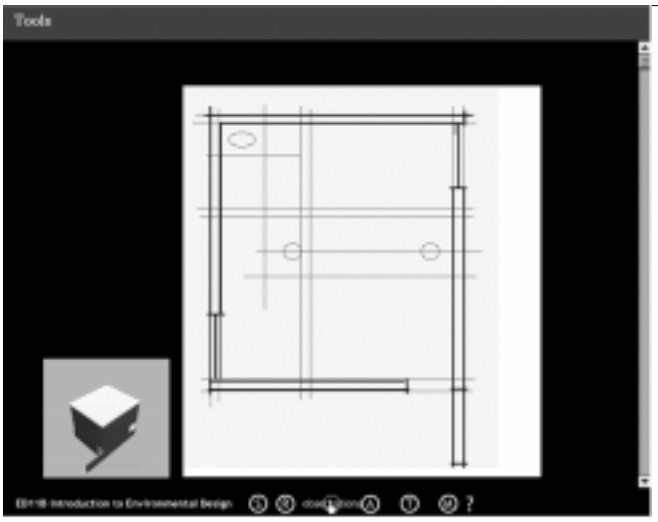

Figure 2. Drawing module. Screen shot showing animation of plan construction.

In bringing the computational technology to design teaching, the connective and communicative qualities of the Web are exploited to promote an exchange among the students. One of the multimedia modules involves gathering and distributing the students' observation sketches. This allows them to utilize others' insights into existing places and gives them the opportunity to see how different values interpret the same place. By providing a setting to exchange ideas and critically discuss approaches this computational support could affect the larger community of students in our university as upper level students would be able to offer their comments and observations as well.

system description

Our work leveraging the affordances of computational media for studio education has two foci: the first is producing content specific to the pedagogical goals of the course; and second, designing an environment to deliver that information to the students. Macromedia *Director* is used as an authoring environment because of its flexibility in distributing the material, the interactive capabilities of its accompanying scripting language (Lingo), and the potential for integration with large visual databases.

Director allows for the same material to be distributed across platforms as well as on the internet, making it a good choice for delivering material to as many of our students as possible. Since the students use the materials independently, outside of class time, access to the material is typically from home, public computing labs in the department, or campus-based shared computers (like those located in a library). At the present time, the materials are available over the internet, from a department server with unrestricted access. As currently implemented, use by the students is voluntary, although the studio content and the lectures explicitly refer to particular computational exercises throughout the semester.

Our strategy in developing the computational exercises has avoided the workbook model for course media, which could result in a mere digital version of the paper handouts. Our ambition has been to utilize the computational media to directly address the previously mentioned inhibitions to learning. The effort does not substitute for any existing course material, but provides a new venue for design learning. Towards this end, five areas of content have been developed and deployed to test ideas about supporting design learning. These content areas are described below and include diagramming form, visualizing drawings, digital video case studies, examining generative structure, and sharing a knowledge base for design.

interactive support for beginning designers

Diagramming Form: During the lectures, students view slides of buildings and places which illustrate various issues, concepts, or systems. These slides have been digitized and distributed over the web so that students can spend time outside class reviewing the images. To increase the didactic content of these images, diagrams are drawn over the scanned slide highlighting structure, dimension, or use. As a reference, a slide of a place typically represents a generalized understanding of a relationship of form–like the orientation of an element or space. The diagramming is annotated to describe the significance of the relationship and is animated to show the isolation of that form within a place. This reinforces "seeing" critically as part of design thinking by isolating a critical aspect of an image relative to the lesson at hand. In the example shown in Figure 1, students are able to access a set of slides of Oak Bluffs on Martha's Vineyard. The orientation of the porches is described in a manner that offers a way of defining the public organization. When students access the reference, they "see" the line being drawn as well as a generic representation of the same relationship. The objective is to link the experience of "seeing" the form with the explicit relational concept.

Visualizing Drawing Construction: To teach the fundamental architectural drawings of plan, section, elevation, and axonometric projection, we developed brief animations that rotate 3D objects. The animations have several components: the object, a plane slicing through it and an overlay of the specified drawing. The 3D objects then fade away leaving only the drawing. The drawing is rendered as it would look drawn by hand, with special attention given to line weights and the order in which elements are drawn (Figure 2). In constructing sequential actions of drawing, the trace

of the drawing's morphological structure is maintained. The course emphasizes process in drawings over presentation and the link to drawing as a morphological structure is an essential lesson. While the presentation of plan, section, and axonometric drawings do not represent an innovation, the ability to show the drawing as an emerging structure changes the way drawings are viewed. The goal is to instill within the student's understanding of technique a greater sense of the drawing as an instrument with which to explore the design.

Digital Video Case Studies: Two plazas on campus were videotaped at various times of day, studying different scenarios of people and place. The intent is to facilitate learning about how experience of a place can be related to design concepts, and how people's use of a space relates to its dimensions. The on-campus site allows students to compare their direct experience of the space with the walk-through on video. About one hour of the site was recorded, then edited and digitized, from which numerous video clips were produced. In addition to the video clips, still frames were taken from the clips with diagrams drawn on them. A narrative text explaining the concept behind the diagram accompanies this composite image. The case studies also include a plan diagram of the major elements and their relationship to each other. In the example (Figure 3), a public space on campus is shown through various angles and at various times of the day. The affect is to observe how the form of the place is used dynamically. Observation of the built-environment is integrated throughout the course work and the experience of the video case studies helps to teach students how to look at and evaluate places. In the module on use and program students are asked to design a stair which promotes a variety of activities. The lesson provided by the video case studies links time, activities, and habitation to a place. Such lessons are present around us, but the computer allows greater systematic descriptions of the relationship between form and use.

Animating Generative Structure: One of the key aspects of a design competence is the ability to see the generative nature of a design–that is, to understand not only the one instance of a design, but to see what else it could become and the struc-

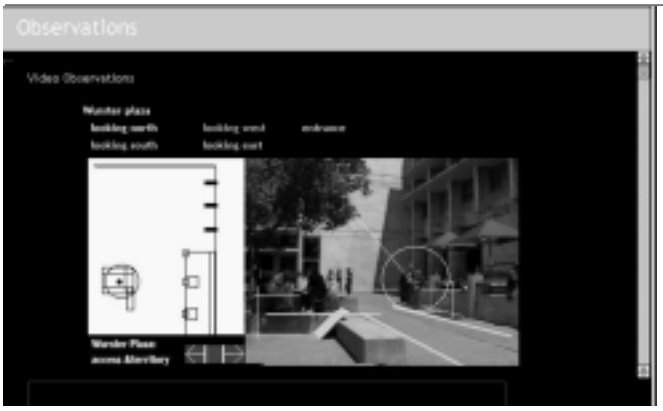

Figure 3. Video case study module. Screen shot of video case study of public space with diagrams and plan.

ture from which to generate other options. In order to help students learn this, a set of animations representing various places is offered. These animations are interactive and can be manipulated. Students view a plan with overlays of one or more compositional structures, like overlays of columns, beams, access, or geometries. After studying the compositional structure, students select a modification to that structure, such as "transform access," and are allowed, within a range of actions, to shift the position of that set of elements on the screen. This then sets in motion a series of animated plans in which the walkway of the original plan transforms by position, size and form. There is a predetermined set of transformations available for four different plans. Figure 4 shows such a set of actions and transformations with a plan showing a building edge. The goal is to demonstrate the actions available within a design and link consequences and values to design actions.

Sharing on the Web: Part of the course's web site is dedicated to fostering a discourse about environmental design. This part of the web site promotes an exchange of design knowledge by providing a place for students to share their observations, critique each other's work, as well as have discourse about problems and discoveries. By looking at multiple responses to the same issue, students improve their ability to see critically and interpret other people's work. Through the web site, students construct a library of their own observations over the course of the semester. Drawings from selected class assignments are scanned and displayed including in-class sketch problems, examples of observation diagrams on index-cards, and images of their configurations created in the generative animation game. The images are stored in a visual database displaying a thumbnail size copy, with the ability to view a larger version. The database can be searched through place, activity, design issues, form, dimensions, type, and author. Figure 5 shows a set of observation cards recalled from a search for "stairplaces" in the database. The images can be linked to a thematic online discussion and students can construct their own sets of references. The observation exercises are a continuous activity in the course and the cards are periodically pinned-up for display. The online database archives this experience allowing for a more careful reading of the observations and more active retrieval of that information. The goal is to overcome the previously mentioned misconception of connecting originality with creativity by allowing students to actively construct a shared discourse from their own observations. This shifts the discussion from one centered on "my" design to one that seeks to understand a shared practice.

evaluation methodology

The impetus for developing these course materials comes from four years of teaching this introductory studio. This experience has led to the formulation of the teaching goals and the identification of the learning issues of the beginning design student. The computational support was implemented and tested during a time when one of the authors was the faculty in charge of the course and had daily contact with the students. This advantageous position gave many opportunities to engage the students in discussions about the course and all its materials. Giving lectures with an intimate knowledge of the contents of the multi-media materials made it easy to draw specific connections between the two formats.

We have evaluated our teaching tools from two perspectives: a user interface viewpoint and a design pedagogy point of view. Prior to implementing the system we undertook some basic usability studies (Nielsen 1994). Since we are more interested in using a rapid prototyping approach to system development, we wanted to use the system as quickly as possible so that we could incorporate feedback into its development. The success of the tool from the users' point of view is being evaluated by using a questionnaire to survey the students who used the materials to determine both how they used the tool and its ease of use. Although clearly we would like to make our set of materials easier to use with subsequent versions, our primary interest in tool building is in teaching fundamental design competence and in developing metrics for evaluating design learning.

We measure the success of the materials in promoting basic design competence by examining two dimensions: how well the students *integrated* the concepts taught in lecture into their design projects, and how well they were able to *ar-*

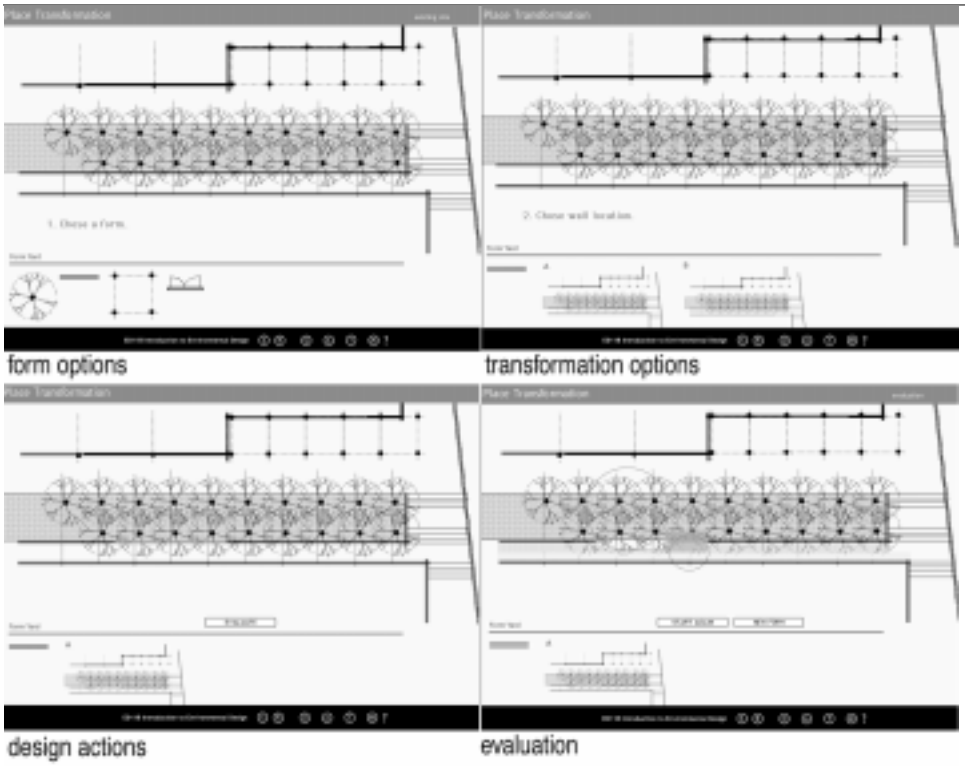

Figure 4. Generative structures module. Series of screens showing transformation sequence.

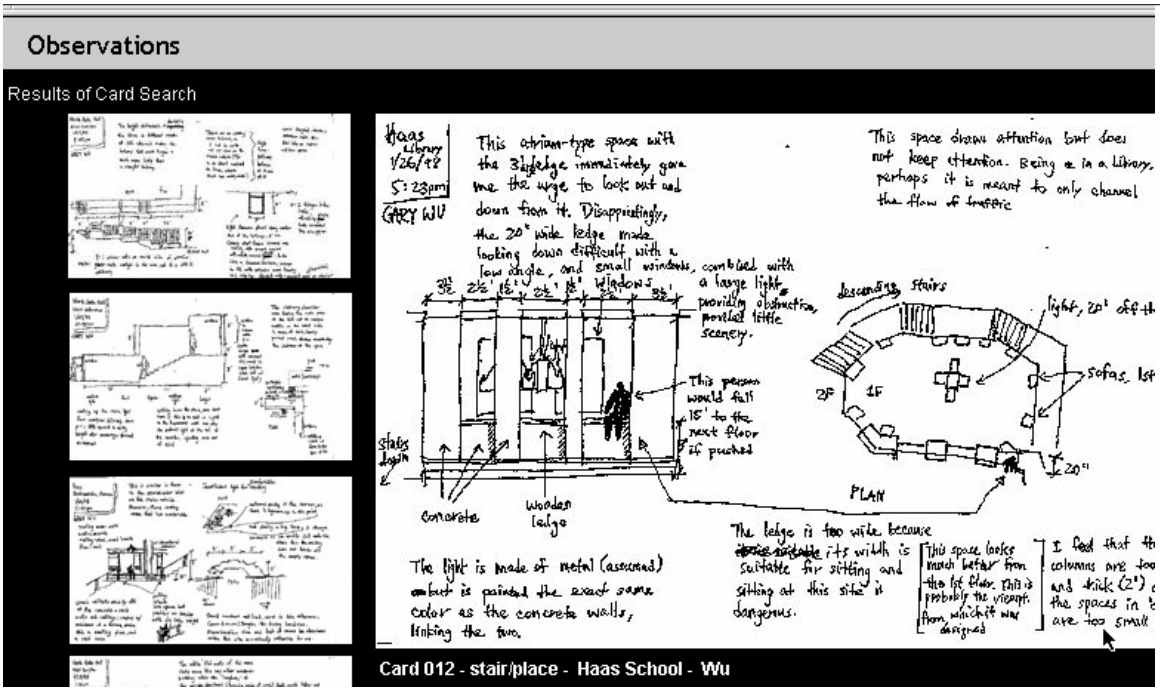

Figure 5. Database of observations. "Stair / places" observations.

ticulate the concepts. The degree of concept integration in the studio work is measured by asking the teaching assistants of each section to rate the level of concept integration for the students in their section. Articulation is measured by a survey of students. The students are shown a diagram or photograph used in the lectures to explain a concept, and then are asked to write a few sentences explaining their understanding of the relationship of that concept to the place. As the system is further developed and more fully used and implemented we hope to develop a background of data around these two dimensions to help us evaluate the impact of the system.

conclusions

The learning that takes place in a studio setting can be characterized as explorative, integrative, projective, and intimate. It should be a place rich in information and direct in its processes. It is also a place with a locale and a culture. To integrate computational support into this learning situation is a challenge. Not only must it add affordances the studio does not have or supports poorly, but it must also have a vibrancy and character equal to learning processes already employed.

We believe that when the inherent qualities for visualization, explicitness, and sharing are exploited, computation support can have a real impact on the studio setting–in our case on helping the beginning designer overcome some of the difficulties in developing their design thinking. In our experience so far, we are convinced that three of the computational exercises have had an impact on design learning. The module on diagramming of references contributes to the development of a visual intelligence by visualizing the act of "seeing" form in a place. The module on transformation contributes to learning design systems by offering a structural explicitness in the way one can manipulate it. Finally, the database of observations contributes to the shared sense of the practice by formalizing the emerging discourse of the studio. We feel there is potential for this courseware to help bridge the gap between lectures and studio time, but there are some limitations to this approach.

Technical issues become critical for insuring distribution of the materials to large classes. Since the course is introductory and attracts predominately new students, many with limited computer experience, we took great pains to insure that the absolute minimum of technical expertise would be required to use the exercises. This decision came at a high price in terms of distributing the materials over the internet. Because our Web site is very graphics intensive, those working at home with slow modems could become frustrated. Large, high-resolution images are important source material for working at a variety of scales; however, there are clear trade-offs between image quality and access speed. In addition to distributing the exercises over the internet, we also plan to produce a CD, which students could either check out from the library to use in a public computing site, or purchase as they currently purchase course readers. The advantages of a CD would be a faster delivery time and greater stability of the media. A CD could also allow us to distribute larger collections of images from our database without relying on more limited internet resources, but can still be integrated into a web site strategy.

A second concern with this approach to supporting design thinking with multimedia courseware is the dilemma of how and when to evaluate the students. The lessons we seek to convey develop slowly throughout the course of a professional life; it is problematic to assume that a few months exposure to new media will produce tangible benefits immediately. It may take considerably longer for the students to synthesize the many lessons disseminated in the introductory course. Evaluating students at different time intervals after they have used the materials might yield different results. One area for further research could involve following a group of students from studio to studio and analyzing how media influence their learning beyond the introductory course. The framework for information delivery we propose could be readily applied to other situations and other courses, most interestingly in later studios. The advantage of solving many of the technical problems after having implemented one example can free us to focus our research on how to support the primary design lessons of more advanced studios and how to integrate multi-media materials into the curricula of other courses.

Despite these technical and evaluative problems, we believe that integrating computational media into the studio offers tremendous potential to better prepare beginning designers to become part of practice. By formalizing a description of design knowledge into a tool for supporting beginning design education, we are also positioning ourselves within a broader research agenda about the nature of design practice and how to describe and communicate the knowledge contained in that practice.

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