Integrating Introductory CAAD Courses and Upper Level Electronic Design Studios

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Abstract: Although the use of computers has become widespread among architecture students, their use in design studios often lacks integration. To gain maximum advantage from computers, design students must acquire a breadth and depth of knowledge that allows them to choose the right tools, integrate multiple technologies, and apply knowledge to new situations. It is not possible for students to gain all of this knowledge in an ad hoc way as part of a design studio. Thus, an introductory CAAD course is a necessary prerequisite for participation in design studios that employ computer methods. The paper presents the experience of two faculty members currently working on the integration of their second year introductory CAAD courses and their fourth year Electronic Design Studios. The paper describes the pedagogical methods used in the introductory CAAD courses, and shows how they serve as the foundation for exercises in upper level electronic design studios. The paper also presents plans for the implementation of distance education methodologies in the delivery of computing and studio courses. The paper ends by providing conclusions that address how the use of computer technology permits the addition of instructional objectives that go beyond those of conventional design studios.

1. Architects and Information Technology

There is clearly a trend toward sophisticated application of information technology in architectural practice. It has been suggested that architects face a critical challenge: either accept the role of knowledge workers and become adept at computing information technology or perish into irrelevance (Mitchell and McCullough 1995). Educating architecture students to thrive in this exploding set of opportunities is challenging. Furthermore, the problem is not likely to go away. The body of knowledge needed to use the variety of architecturally useful tools is considerable. It is not reasonable to expect students to "pick it up" in high school or on their own, or even in a liberal arts collegiate curriculum. On the other hand, a design studio that depends upon computing methods must avoid becoming purely training in how to use the hardware and software. There is now a need and will continue to be a need to integrate specialized courses in information technology into the foundation level of the architecture curriculum. Foundation courses in computing must then support the anticipated demands of studios that use computers. However, identifying exactly what will be the needs of studios is difficult. Information technology and its applications is are changing too rapidly to allow characterizations that are not likely to be quickly out of date.

In the development of a comprehensive computing requirements model for Design Studios, CAAD instructors and Studio instructors need to work closely together. This is difficult if studio instructors and CAAD instructors are seen as divergent in their vision of the profession. Under such circumstances, CAAD instructors are stereotyped as computer nerds fascinated with useless applications of computing power. At best, CAAD instructors are given the credit of addressing presentation techniques, but even then, one constantly comes across criticism on how computer-adept students think they can get away with mediocre design presented through glossy computer generated imagery. On the other hand, Design Studio instructors are frequently stereotyped as techno-phobics that concentrate their effort on highlighting what computers can not do in a design process and underline the magic embodied in free-hand sketching as core of the design process.

In an instructional environment where Studio studio instructors and CAAD instructors have managed to establish and maintain open communication channels, one finds that Studio instructors recognize the potential of computing in the design process, and CAAD instructors recognize the potential of free-hand sketching at the core of that same process. However, it must be noted that in order to develop a comprehensive computing requirements model for Design design Studiosstudios, CAAD instructors and Studio studio instructors need tomust go beyond the maintenance of communication channels, ; they need tomust collaborate in each othersother’s syllabus development. This can be accomplished through two methods, namely:; 1.-) Team team Teaching teaching in both foundation courses in computing and design studio;. 2.-) Double double Teaching teaching Assignments assignments in both foundation courses in computing and design studio. Each method poses particular challenges. In the case of Team team

Teachingteaching, faculty needs tomust invest considerable time to learn from each other and produce a synthesis of knowledge that is both personal, from a design perspective, and dynamic, from a computing perspective. On the other hand, Double double Teaching teaching Assignments assignments requires the recruiting of faculty with an unusual combination of talents that remains to be scarce and the placement of considerable teaching loads on themthose individuals.

The authors each have double teaching assignments in boththat include both foundation courses in computing and design studio. Drawing upon those dual perspectives, we each have developed approaches to how computers should be used in studio and the foundation knowledge to prepare students for studio computing. However, there are common themes between our individual approaches. We each cover computer graphics, but also attend to business applications. Network computing has grown in importance to be a major part of our courses. In our studio courses, our strategies emphasize two different approaches to architectural computing: in the first approach described below, the emphasis is upon a knowledge market and problem-solving by integration across disciplines, while in the second approach, the emphasis is upon a global market and communications tools.

2. Information Technology in Design Studios

Traditionally, the studio has been the educational vehicle for conveying to students the skills of integrating a wide range of other subjects into the synthetic activity of design (Schön 1987). As studio instructors, we are taking advantage of the studio format to provide students with experiences in integrating and orchestrating the wide variety of computing applications. However, to take this integrative step and apply computers successfully to design problems requires that students obtain an impressive range of knowledge. Introductory computing courses are necessary to equip students with the range of fundamental tools that must be applied in studio to make this integrative step.

To reinforce this image of what studio computing could be like, wWe present an ideal (two visions) of studio computing in the form of a scenario (two scenarios visions of how students should use computers in studio courses. It is important to note that none of our students have achieved our visions. In the first vision, the emphasis is upon how the architect can use computer tools to be more effective in a knowledge market. The second vision emphasizes the demands of working in a global market. In it, digital communication media play a key role in facilitating cooperation and collaboration. For each vision, we describe a scenario of how students should use computers in design studios. We present a selection of exercises that we have developed to enable students to move toward the visions. and their related foundation computing courses). The two visions are not distinct or conflicting but differ more in focus than scene. Consequently, we will also describe the common core of our foundation computing courses.

It is important to note that none of our students have achieved this ideal (our visions). The scenarios presupposes an upper year architecture student working on a commercial building in collaboration (interaction) with classmates (with other design agents).

3. Vision #1: The Architect in a Knowledge Market

The first vision emphasizes many disciplines and ways of thinking about architectural design. In his protocol studies of architecture instructors, Schön observed that master architects alternate rapidly among many frames of reference or disciplines of knowledge (1987). The goal of an architect, as distinct from other contributors to the design and construction process, is to achieve a successful integration of many functional systems (Rush 1986). In this first vision, computers are used to integrate a variety of kinds of information and diverse fields of knowledge. The architect of the future uses software to marshal tools and knowledge from other design disciplines and applies a variety of knowledge to achieve a greater synthesis and integration. The vision builds from the problem-solving and knowledge-based activity views of design.

A scenario illustrates the vision of how students should design. The scenario describes an hour or so of work part way through the building design project. The student is seated at a fully equipped, networked personal computer. The student's current task is to design the lobby of the building. The student is employing a 3D modeling program to place elements and view the resulting spaces.

A question arises of how to design a glass curtain wall. The student switches to a Web browser to collect information on curtain walls. On-line design resources in the form of CD-ROM's on the College network, such as Architectural Graphic Standards or Sweet's Catalogues, provide more information.

After opening a word processor, the student jots down notes on alternative products. Images are grabbed from Web pages and pasted into the written document. The student uses an outline to organize the notes into a hierarchy of topics and subtopics.

Having selected a curtain wall technology, the student uses a drafting program to work out precise spacing of mullions, perhaps parametrically. The drafting program records the sections through the mullions, the critical dimensions, the size of glass panes, and the pattern of the curtain wall in elevation. Alternative fenestration patterns raise new questions.

By querying from a college database of cost information, the student collects information to support a decision. The data is inserted into a spreadsheet program to study alternative cost projections. The student checks the cost of the curtain wall with respect to other building costs to determine if they are within expectations.

Having tentatively decided upon a particular fenestration pattern, the student imports the drafted representation into a 3D model and refines the idea in 3D. The student adjusts the light to see the shadows cast by the mullions at an appropriate time in the afternoon. Solar animations allow the student to determine whether the shading devices work properly. Walk-through animations show how a visitor will move through the space. A rendering is saved to disk and imported into a paint program for retouching. Using the paint program, the student adds a tree and some shrubbery to an indoor planter box.

The documents, such as written text, VRML models, scripted animations, polished renderings, and 2D CAD drawings as DWF files are integrated into a Web site. Students and faculty may inspect the Web site and provide critiques.

The scenario presumes several conditions regarding both technology and student skills. It depends upon general-purpose computers with large capacity, powerful processors, and equipped with a wide variety of software; it would not be practical to work like this when the software applications are segregated each to a different machine. The students must be confident with each software tool, possessing not only an acquaintance with all of the tools but adeptness. Furthermore, the students must have an understanding of the boundaries among tools and how the information must be transformed when moving from one application to another. For example, the vector graphics of the CAD systems must be transformed into raster graphics for use in the paint program and the cost information from the database must be imported into the spreadsheet.

4. Vision #2: The Architect in a Global Market

In this vision there is an emphasis on the globalization of design markets and the support of international collaborative design activities. More so than the previously described vision, the emphasis is upon architectural design as a social activity. Due to such an emphasis, in addition to a fully equipped and networked personal computer, the students also have access to studio-to-studio videoconferencing facilities that permit real-time interaction between several design agents in different locations (Vasquez de Velasco and Jimenez 1997).

The student's current task is to design the lobby bar of a five-star hotel located in the business district of downtown Mexico City. The hotel is a semester-long design exercise in which the students present three projects addressing Site Planning, Project Development, and Detail Design. The scenario described corresponds to the Project Development stage. Collaboration takes place between students in the United States and others in Mexico.

Without previous experience in the social dynamics that a lobby bar in Mexico City must support, the student must initially engage in collecting information to provide a context and background for design. For a first approximation of a solution, the student explores the Web, searching for information on 5 and 4 star hotels in Mexico City. The student is particularly interested in images of other lobby bars in Mexico. After looking at a few images, the student uses a videoconferencing link with fellow design students in Mexico City to inquire about the multiple scenarios that Mexican natives can generate in a lobby bar. Based on the comments of Mexican students and a Web review of design standards for food and beverage establishments, the student uses a word processor and a spreadsheet program to develop and produce a program of requirements for the project.

Using 3D CAD models of the hotel lobby where the bar is to be located, the student extracts orthogonal and perspective images, and exports such images as raster graphics. Opening a raster editor, the student sketches a few ideas of layout on top of the image of the lobby's floor plan and section. The student can also sketch a related 3D image on top of a perspective of the lobby. Information about colors, furniture, and even human figures are added as the student explores the potential of a particular set of design inferences.

While keeping the raster editor open, the student re-opens the vector CAD editor and the word processor/spread sheet program. With all the programs open, the student transfers the original ideas from the raster-based sketch to the vector-based floor plan wile keeping in mind the program of requirements. Once the raster-to-vector transfer is accomplished, the student uses the 2D information to generate a 3D model of the new bar design in the existing 3D model of the lobby. The model is rendered to display the student's choice of materials, design for artificial light and the impact of the natural light parameters imposed by the location and orientation of the project.

For collective assessment of the proposal and the initiation of a new design cycle, the CAD 3D model is exported in VRML format and made accessible through the Web to the students in Mexico. The Mexican students can make use of the VRML model to navigate through the project. The Mexican students can follow imbedded hyperlinks to retrieve high quality rendered images of the project. Making use of a split-screen or screen-in-the-screen interface in the videoconferencing system, a student can simultaneously display movement through the VRML model and his or her own image in the process of commenting the project. Any of the fields or windows of the interface can be replaced by additional sources that may include interactive raster or vector editors. In such a way, a new design cycle, now at a collective level, can be initiated.

For the presentation of the project, the student imports the 3D model of the project into an animation program and produces an animation. The animation and still renderings are imported into a multimedia editor program. From the multimedia editor, the student can print frames for display on pin-up boards, encapsulate the material in a run-time program that can be distributed in CD-ROM format, or encapsulate the material in Java format for delivery through the Web.

As in the case of the scenario described under Vision #1, the scenario described under Vision #2 also requires access to general-purpose computers with large capacity, powerful processors, and diversified software. It must be noted that in accordance with the scenarios described above, the existence of redundancy in software is desirable. Students must have more than one choice when it comes to selection of a word processor, a bit-map editor, a vector editor, or a solid modeling package. Students must be offered the potential to discover that within a single software typology there are a number of similarities as well as differences. In that same spirit, it may be desirable to maintain a number of computers that diversify the hardware platforms in which the students can work. Under ideal conditions the scenario previously described should motivate students to use PC, Mac, and UNIX computers on an opportunistic basis.

Once the connection is established during videoconferencing sessions, the students should have direct control of the equipment and the way in which they present their projects. The assistance of a videoconferencing facilitator would be intrusive in a design review scenario.

5. Common Objectives for Foundation Computing Courses

Although the focus upon architects in a knowledge market differs from the focus upon a global market, many of the foundation skills needed are the same. In this section we will describe the common objectives of the two variants of the foundation course who are responsible for foundation computing courses.

Computing basics: A primary objective is to provide remedial knowledge in computing basics. Enrollment in the foundation course is open; there are no computing prerequisite courses. Consequently, some students entering the course have little or no computing skills. These students must become part of the computing culture to enable them to have any opportunity to succeed in the advanced studios. Other students enter the class with a large amount of knowledge of computing. Nevertheless, because of our emphasis upon breadth of skills, nearly all students are lacking in some important area. Most entering students have misconceptions, incomplete knowledge, narrowly limited knowledge or no knowledge.

Students with poor skills need to be introduced to categories of hardware, the basic distinction between software and data, the use of operating systems, and the myriad details of computing folklore, etiquette, gesture, and jargon. We also encourage students who do not own a computer to begin researching the purchase of their own computers.

It is a challenge to pace the course to satisfy all students. One approach to accommodating the wide range of students is to provide tutorials or lab instructions on the Web. Students can then move through the course at their own pace (Figure 1,2,3).

Breadth of knowledge: Both the vision of architects in a knowledge market and the vision of architects in a global market depend upon students achieving a wide-ranging knowledge of many applications of computing. Business applications are fundamental to both the solution of practical problems and negotiation between collaborators. Communication tools, such as e-mail, Web browsing, Web authoring and VRML, not only enable a student to collect and contribute to the knowledge of architecture, but also support distributed design teams. Raster image editing and CAD are clearly fundamental tools for expressing space and form. A student must be able to move freely among all of these tools.

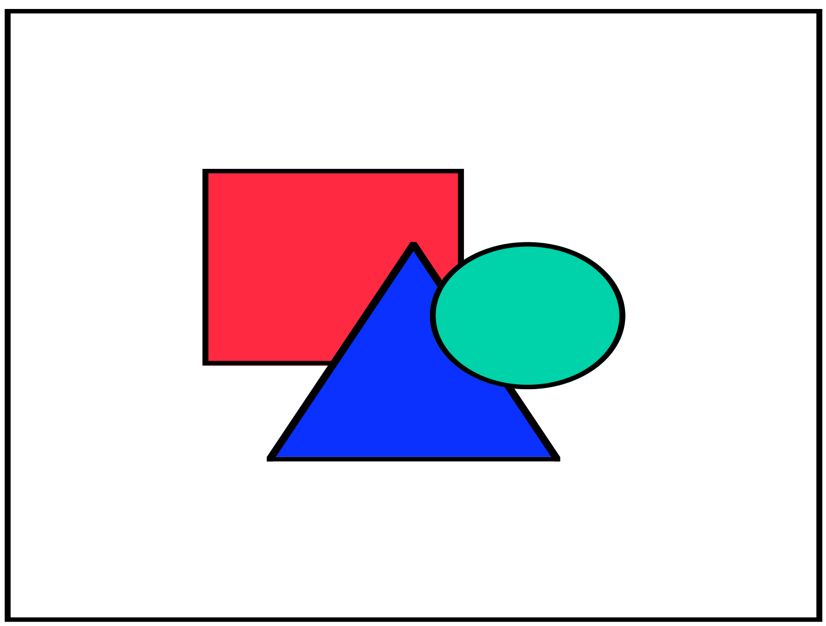

Figure 1. Title screen of the instructional program used in one of the CAAD courses

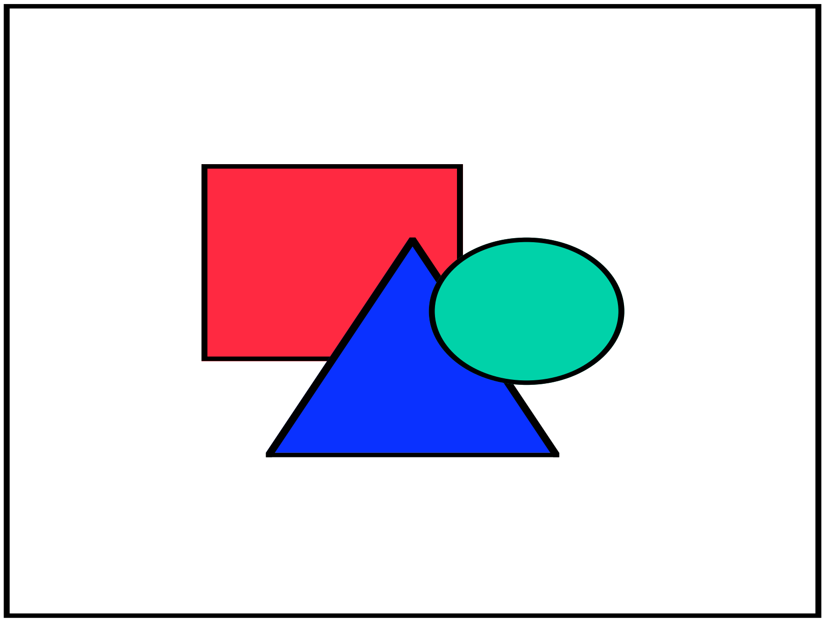

Figure 2. Front end screen showing main instructional subjects

Effective use of computers: The profusion of software that we use in our courses requires considerable effort directed toward the mechanics of operating software. Courses with a strong computing component are always in danger of becoming merely software training. However, effective use of computers involves a focus upon tasks and objectives that relate to problems in architecture. In most cases, the solution of real problems will require the use of many software packages. Students must obtain an ability to choose the right tool and move information among many software packages. Effective use of computers depends upon integration of many forms of information and many different software tools. A key to students' success with computer methods is to learn the conceptual routes by which they can transform data into useful information using many different computers and many software packages (Von Wodtke 1993).

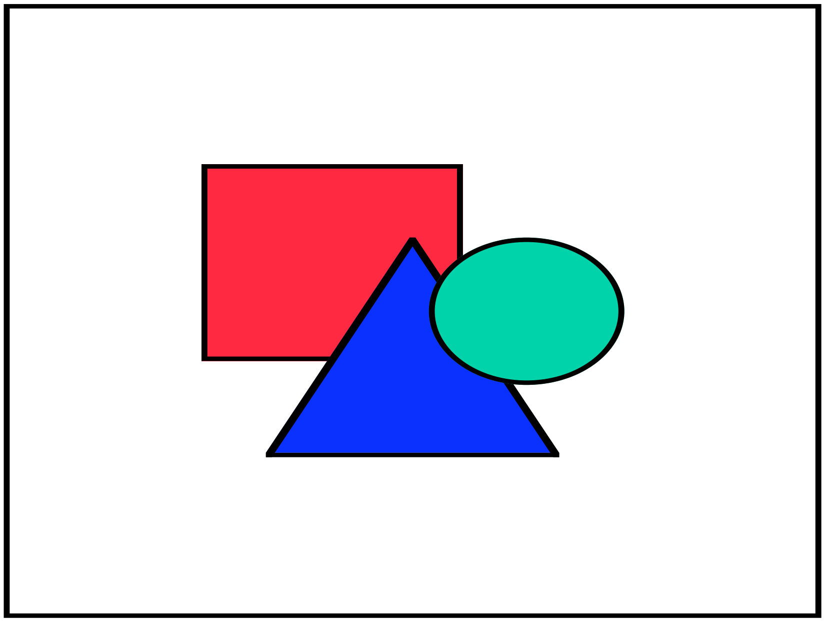

Figure 3. Content screen on the subject of Surface & Solid Modeling

Both of our visions of studio computing depend upon use of "fully loaded" but general-purpose computers. Although there may be a sacrifice in graphics processing capability or inability to run cutting-edge software, we prefer "Wintel" computers because they allow us to load a variety of software. Using the Wintel platform, our students can run a word processor, a spreadsheet, a Web browser, an e-mail program, a CAD system and a raster image editor all at one time and smoothly move information among the different software. In the future, we hope to incorporate Internet-based collaboration tools (Clayton et al 1997), such as Microsoft NetMeeting, to provide an enhanced ability to conduct "desk crits" from remote locations.

Skills in learning: In response to the rapid changes that computing undergoes on a continuous basis, it is important that students of architectural computing be equipped to teach themselves in the future. Some of the knowledge that enables continuous learning is merely technical. Students should be accustomed to on-line help systems. They should be familiar with using the Web for software support, chat rooms and news groups for acquiring and sharing tips, and e-mail for asking for help. They should be able to turn to published textbooks and paper-based material when those are the best sources of information.

Additionally, a foundation course must provide students with a conceptual framework for architectural computing and information technology. Our courses include lectures that present material in more abstract form as well as lab exercises that embody "learning by doing."

Active participation in the computing culture: At the broadest level, our objective is to initiate students into the computing culture as active and contributing participants. We wish our students to become immersed in computing as the natural way of doing architecture. Although their current experiences with computing still frequently include frustration, many of our studio students rely upon computers for every aspect of their design studies. As these students enter the building and design professions, we hope that they will be able to apply their understanding of "information technology" to the practical problems of their clients and our society.

6. Conclusions

The process of implementing computing foundation courses and electronic design studios that address the two visions previously outlined, has resulted on a number of fundamental as well as practical conclusions:

In fundamental terms, we have come to terms with the fact that it is not reasonable to expect students to "pick up" computing in high school or on their own, or even in a liberal arts collegiate curriculum. Foundation courses in computing must be especially designed to support the anticipated demands of studios that use computers. To develop a comprehensive computing requirements model for Design Studios, CAAD instructors and studio instructors must go beyond the maintenance of communication channels, ; they must collaborate in each other's syllabus development. This kind of integration can be achieved by means of "Team Teaching" or "Double Teaching Assignments".

In terms of instructional objectives, students must be offered learning opportunities that provide remedial knowledge, breadth of knowledge, effective use of computers, and skills in learning computing. Students must be able to experience how a design process can provide a framework for integrating and orchestrating a wide variety of computing applications in an opportunistic basis.

In practical terms, computing foundation courses need to be strongly "learner centered" in their methods. Most of the practical knowledge that our students will acquire in a second year course will not be used in an actual job. The students will be mainly learning how to learn. Our teaching methods need to address this fact and resemble methods used for continuing professional development. The use of distance learning and on-demand learning methods is very relevant.

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