Educational Research in the Third-Year Design Curriculum: Visualizing the Design Science Process with Information Technology

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PREMISE

The third year design experience is to culminate with a student's capability to present recognizable patterns of built form in which each system of a building demonstrates its own logic and necessity as they impact one another, Fig. 1. The successful attainment of integrative design thinking as an objective—which is always difficult—has been further complicated by the growing demand to introduce information technologies into the professional design training of our students. We have confronted this problem from the following two positions: 1) How may information technologies be introduced into the design process to extend the traditional approaches and tools at the architect's disposal without a loss of synthetic growth by the students or a compromise to instructional pedagogy? 2) How can the introduction of information technology provide a useful learning structure that will inform student understanding and professional judgment across the traditional boundaries that have formed between the studio and lecture settings?

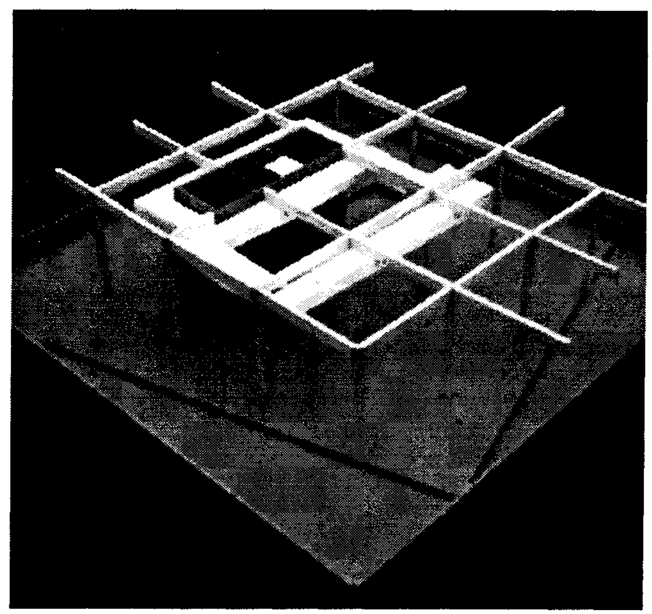

Fig. 1. Structural/Mechanical System Model. Heather Torents, third-year Student, 1998.

BACKGROUND[1]

Our primary concern in teaching third year studio has been to improve our students' development of their analytic capabilities, their understanding of the design process, and address the demands that the integration of all building systems require. We have undertaken a restructuring of the studio design teaching model in an effort to improve our teaching, but has since become a funded research effort to improve the delivery of the design science content within the third-year curriculum. The task has been made possible by our embrace of information technologies as a common thread in both lecture and studio settings.

Beginning in 1996, information technology processes have been introduced into the first and second year design studios at our institution. In the fall semester of 1998, the first class of architecture students possessing personal computers entered the required third year of studio design. The leading wave of students with personal computers have caused many of our faculty to re-appraise their teaching approaches, as well as endure the struggle to provide the facility with network communication, hardware, and software capabilities to accommodate an integrated use of information technology.

In anticipation of this wave, we began to restructure the third-year studio pedagogy during the summer of 1997. This permitted us to test the feasibility of an approach that we considered reasonable during the fall semester of 1997, **without** the use of personal computers. On the basis of that effort, we submitted a research proposal to our institution to undertake the initial tasks of planning for an instructional and curricular shift during the summer of 1998. The first implementation of our ideas with the use of personal computers by the students at their studio stations occurred in the fall semester of 1998.[2]

PROJECT DESCRIPTION

Our proposal sought support for the development of computer-aided-design learning modules to be developed for the required third-year core courses, including studio design, ARCH 3101, Structures I, ARCH 3141, and environmental forces, ARCH 3142. These courses occur in the first and second semester of the third year of the College of Architecture's (COA's) five-year professional program. This studio is the first building design course that focuses upon the integration of technological issues within the architectural design process.

The proposed teaching modules sought to extend the current series of technological issues introduced throughout the third-year. The technological issues have been broken down into five specifically tailored content areas addressing: I. Site and Climate Assessment: II. Building Programme and Spatial Assessment: III. Structural Planning and Building Systems Integration: IV. Material Composition/Assemblage and Building Enclosure: V. Architectural Systems Integration:

The content areas address essential knowledge and skill development that must be addressed in studio to enable the student to develop sound design judgment. Mastery of these content areas are crucial to the student's continued success through more advanced professional requirements. Each content area contributes to maintaining College accreditation through the fulfillment of the National Architectural Accreditation Board's (NAAB) guidelines for Student Performance Criteria.

The structure of each learning module as well as the semester schedule have been framed to correspond with the educational objectives of improving the student's knowledge development, comprehension, application, analysis, synthesis, and evaluative skills as identified within Bloom's, *Taxonomy of Educational Objectives*.[3]

METHOD

In each of the five content areas identified above, we initially sought to employ a corresponding computer application that would support knowledge building, and advance the opportunity for students to run multiple design analysis scenarios to strengthen their decision making skills. We sought out specific software applications that could be applied across both studio and lecture settings to insure the widest range of student skill development and comprehension. Because of the diversity of tasks that occur across both settings, as well as the graphically oriented nature of the architectural student, we identified the need for professional level programs that successfully provide both numerical and graphical displays in a manner that permits rapid model simulation. We targeted the following computer programs as initial points of departure for studio and lecture instruction:

- I. Site and Climate Assessment: *CLIMATE CONSULTANT*
- II. Building Programme and Spatial Assessment: *POWER CADD* and *DESIGN WORKSHOP*
- III. Structural Planning and Building Systems Coordination: *MULTI-FRAME*
- IV. Material Composition/Assemblage and Building Enclosure: *SOLAR 2* and *OPAQUE*
- V. Architectural Systems Integration: *SOLAR 2 & 5, MULTI-FRAME, POWER CADD*, and *DESIGNWORKSHOP*.

PRELIMINARY TEACHING MODULE CONTENT: *FORMAT AND PROBLEM STRUCTURE*

While we identified five topical areas for development, the demands of the semester time limits and our concern for student comprehension of the visualization and integrative skill development objectives have caused us to approach the teaching from four topical groupings: **Module 1**: Climate/Site/Spatial Zoning Analysis; **Module 2**: Spatial/Structural Analysis; **Module 3**: Structural/Material/Enclosure; **Module 4**: Systemic Analysis - Synthesis

Each module will consist of the following: 1) key reference texts for the discipline in each area of concern; 2) one required reading, explaining the key concepts and approach. Required readings will include three supplementary articles that are nationally recognized, addressing each topical area with one selected by each faculty member; 3) a summary sheet that provides an outlined overview to each topical realm and presents key terminology with definitions from required readings; 4) illustrative teaching examples in the computer program selected for the development of each topical area. The teaching examples are to illustrate key scientific and technological principles suitable for students undergoing third-year first semester studio design development:

- the use of Froebil Blocks as a base demonstration of principles;
- the use of a built example, having either national recognition as work of architecture;

5) Problem statement preparation framed as an extension of the teaching examples and directed at the learning objectives that will include topical lectures to introduce principals to students including building case study examples; 6) student solution where students prepare their work in the following three areas for each topic:

- Graphical/numerical analysis on the computer;
- Physical modeling;
- Sketch analysis/synthesis based on what was learned from steps A and B.

The learning module documentation, computer programs, and problem statements with sample problems, will be the fundamental component of the course syllabus for ARCH 3101 at the beginning of the fall semester of 1999.

SEMESTER STRUCTURE

The semester structure that we adopted in the summer of 1997 and revised in the summer of 1998 is comprised of three phases, based upon the notion that learning requires the presentation of key principals and then their repetition with progressive elaboration (see Figure 2).

This apparently simple decision was rooted in our observations that students generally tend to change too many variables at each step of the design process to really learn how things are inter-related; that the range of knowledge often overwhelms students; and that analysis techniques presented in lecture generally fail to be applied in the studio setting.

Phase I: Process Introduction (6 weeks)

A series of exercises were developed during the summer of 1997 that addresses each of the five topical areas. The problem statements were linked in a progressive manner to one another, demonstrating the dependence of each new topic upon those that went before. The sequential process was programmatically straightforward, informational, sought tool and process development, and was summative. We chose to make these quick one week exercises for several reasons: 1. To enable the repetition of a full design problem within the limited time of one semester, and; 2. To insure the introduction of knowledge would be kept to essential issues with references provided for their elaboration, and; 3. To insure the examination of the problem would result in a specific and limited response bypassing the student urge to find the "best" solution and deliberate on their potential options. We encouraged the students to go (almost) directly to the most simple and straight forward solution that could be found, emphasizing the importance of process and the inter-related nature of each issue.

Phase II. Process Application (7 weeks)

The design process introduced to the students in the first six weeks is immediately reapplied by the students in a brief four-hour design charrette at the start of Phase II. We take the students on a

Studio Schedule Fall 1997: Swanson

Date/Day	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Aug 25-29	Prelim problem				prelim prob	
Sept 1-5	Labor Day		1 site analysis and geophysical			
Sep 8-12	1 due		2 Site develop & space zon'g			
Sep 15-19	2 due		Mtg w/Levine 3 Systemics, circul., intrstitial, structural order			
Sep 22-26	3 due		4. mat'l order and enclosure			
Sep 29-3	4 due		5 Integration/notebook			
Oct 6-10	5 due		Fall Field Trip: Washington, DC/Problem 2			
Oct 13-17	Fall Recess					
Oct 20-24						
Oct 27-31			block fest			
Nov 3-7						
Nov 10-14			bldg comp prob 2			
Nov 17-21						
Nov 24-28	muse crit/review		Thanksgiving Break			
Dec 1-5						
Dec 8-12	Jury Week		Final Crit w/block comp			
Dec 15-19	Final Exam Week					

3rd yr Studio Schedule Fall 1998: Brentrup, Nelson, Swanson

Date/Day	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
Aug 24-28	1.1 Prelim prob.		Lecture D. 1.2 site and geophysical readings		Cornelius Site Visit	
Aug 31-4	Site anal due Cone Center: Climate Context /Spatial Pln'g		Lect D. in Univ City Library			
Sep 7-11	Labor Day				#1.2 due 1.3 Spatial & Systemic order	
Sep 14-18	Struct. Exam I				Mt Airy Trip?	
Sep 21-25			#1.3 due, #1.4 hndot, struct Mat'l Encl. Prob	Heath Exam I	Lect. Struct /Matrl/Envel Order J	
Sep 28-2	Struct. Exam II					
Oct 5-9	#1.4 due 2.1 hndot, trip		Fall Field Trip:Asheville Wed 2PM depart, site visit; Th morn, gath info; aft. site anal. even. charr; Fri. review & site, charr 2 even return.			
Oct 12-16	Fall Recess		Lect systemics D, J. R. (in studio review)			
Oct 19-23	2.1 due site & schem in design wkshp 2.2 Mat'l mat'l lec hndot		lect. stl/blck/ const integ J.D.R	Heath Exam II	blockplant visit	
Oct 26-30	Struct. Exam III					
Nov 2-6						
Nov 9-13	2.2 due lgr scale Mat'l light'g struc sec dev 2.3 systemic					
Nov 16-20	Struct. Exam IV					
Nov 23-27	2.3 Final Presentation		Thanksgiving Break			
Nov. 30 - 4	Presentation think'g block comp prep	Heath Paper Due				
Dec 7-11	Jury Week	Block Comp Due @ 10 AM Sharp.	Finals w/block comp.	Heath Exam III		
Dec 14-18	Final Exam Week					

Fig. 2 Fall Semester Calendar 1997; Revised Fall Semester Calendar 1998; One week/issue Format 4-part module sequence covering five issues

field trip, permitting them to do some first hand investigation on an existing facility type that would be addressed during the rest of the semester. After a one day tour of two to three facilities that involves discussion with the administration and building engineering staff, a group charrette is begun that involves a shared dinner which culminates in a team design response within a four hour time period. During this time, we help the students manage their time to move them quickly through the process, simplifying the drawing requirements so that they can all come close to getting their ideas set down.

Iteration, Elaboration, and Synthesis: Upon return to school, (and in our case, after a brief fall break) we set out in earnest addressing the new site constraints/opportunities of increased complexity continuing with the building type introduced on the field trip. The new problem generally has an increase in scale with a modest increase in complexity of site and building planning. We take the students again through the sequence of tasks with a brief increase of the time allowed for student investigation and development. The students are provided with a lecture concerning the issue of system integration as well as some fundamental techniques for the coordination of building systems. The new requirement of demonstrating synthetic development is facilitated by a change in the scale of the models and drawings to be performed.

Phase III. Demonstration of Design Synthesis and Design Competition (1 week)

Given a specific and limiting format, the students are asked to compose their work from Phase II with the purpose of demonstrating their synthetic capabilities and design investigation. Within the format each student is expected to present their work through graphical/numerical analysis on the computer, physical modeling, and sketch analysis/synthesis. This activity is intended to focus on a design investigation of masonry products, and has been given generous support by local construction/material associations by sponsoring both field activities and monetary awards.

COMPARATIVE ASSESSMENT OF EACH APPROACH

Our assessment will examine the relation between the proposed course problems, positive and negative impacts of introducing computer applications into studio and their relevance in achieving third year design education goals.

As we compare what occurred during the first and second approach, we are agreed that the students of the first approach appeared more confused in their efforts at integrating various building systems into their designs. The second group worked and struggled harder to demonstrate synthesis which resulted in an improvement of the constructive order and luminous environment of their projects. We attribute this change first, to the introduction of two topics into an expanded learning module in the second session rather than one topic on a weekly basis in the first, and secondly, to a collaborative studio experience across all sections rather than each section working somewhat independently. We do not believe that the use of the computer affected this change one way or the other.

In our second approach, the decision to issue the semester's studio problems using one building type on two different sites, also improved the student's opportunity to succeed at integration, whereas in the first approach we had used two different building types on two different sites. Again, improved student work was not dependent upon the presence or absence of I.T. in the studio, but rather on the opportunity to address integration without the necessity of reexamining an entirely new design problem. This structure and the five studio issue areas will remain as the core studio structure as we continue to refine our studio and seminar teaching.

The contributions to the studio experience due to the presence of I.T. and comprehensive software programs were as follows: Surprisingly, more students hesitated to use I.T. than we anticipated. The fear or distaste for the machine was attributed to its tampering or interfering with an expression of a personal vision, and to a certain fear that an expertise in the use of I.T. would pigeonhole a young designer to the dustbin of a CAD drafting position when they got out into the field. In roughly 10 percent of our students, these issues remained nonnegotiable.

As a positive contribution, we did notice that the students in the second approach asked more questions than the prior class and had a heightened curiosity. The use of comprehensive software programs opened the eyes of the students to the scope of knowledge that can be required to make sound design decisions. It is likely that the greater sensitivity of the student work to third-year design criteria in the second approach is attributable to the presence of I.T. and comprehensive software in the studio. Digital modeling enabled students to see almost immediately, the extent to which changes in design criteria could impact a general design parameter. Design suddenly became more than an activity of rearranging boxes on a piece of tracing paper. Many of our students reported that technical issues provided opportunities for fresh design insight. The actual contribution of I.T. to improving student's skill at analysis is too early to tell and the issue may take several semesters of observation and evaluation to gage. But, we did find a willingness by most students to engage technical issues in a meaningful way to be refreshing and that the use of I.T. probably contributed to improved student performance across our third-year.

As a hindrance, the presence of I.T. and comprehensive software in the studio could easily become a sinkhole of student and faculty time. Not enough time or attention could be devoted to tutoring students on the software in studio. Also, the ease with which students could delve into the unnecessary details of a problem—for which we weren't prepared— required the development of a sense of humor and a new callousness to personal embarrassment. We discovered that the software or hardware usually worked when they were not needed, and conversely, didn't work well when it was imperative. Because of this, we have now taken the general view that lecture and seminar are the appropriate venue to instruct the students in the use of software, that studio is for software application, and that the two forms of instruction must occur in tandem. Clearly there is a need for the development of studio learning modules based on professional software that can be tailored to the development of student and educational objectives.

We are re-evaluating our selection of the CAD software being introduce at this level of design education. The third-year presents a level of complexity which demands tools with depth for continued development. We are now exploring several software packages that will permit our students to grow through the rest of their education and be prepared for professional practice.

As we continue to refine our course and studio structure, our first tinkering will be to improve the opportunities for students to learn the fundamentals of the various design/analysis software packages that have been selected. We will also seek to redefine our division of labor permitting each of us as faculty to take greater advantage of our individual strengths. We recognize that there may be a bit of danger in this, since our efforts are directed toward the development of an integrative designer, and it is probably best that the students learn directly from individuals who strive to demonstrate these capabilities, rather than present a segment of those capabilities. This means that we will have to become more familiar with all the software packages that we are introducing as well as the development of our sense of humor.

CONCLUSION

Artful building design cannot afford to be based solely upon a glib personal response nor left solely to the results of a numerical analysis optimizing a single system's performance. Because we shared this point of view, we found a systemic approach, involving multi-tasks within multiple layers of a design problem, to present a significant model that leads to student self discovery, when linked to the introduction of software that is designed to solve specific problems within the design process. While it is too early to be sure, we suspect that the observed increase in the number of students who have successfully grappled with the synthetic component demands, did so for the following reasons: 1) The five issue areas were placed into four teaching modules in which the issues now overlap, forcing a recognition of their interrelationships; 2) A contributing factor to this improvement we attribute to a change in the review structure.

The general assets of this approach resulted in a common review process across three studios where the problems, process, and evaluation method provided a coherent experience, expectations, and a better understanding of the problem statements; an interconnective process that supports a multiple scenario approach that provides a greater chance of improvement for student visualization and integrative capabilities.

The general drawbacks to this approach are that the comprehensive structure of issues leaves little time for students or faculty; student reactions to the use of information technology for analysis exercises were mixed, ranging from the need for more time to learn the software to a dislike of the inclusion of analysis tasks in a studio setting.

The coordination of studio teaching with a modular structure involving computer applications presents a unique effort in architectural education. The preliminary teaching module will be reviewed by outside experts before fall class begins in 1999 as well as a professional educational researcher to more accurately pinpoint the improvements and liabilities of this approach.

NOTES

[1] Funding of $25,000 for this research has been jointly provided from the University of North Carolina Charlotte and from the College of Architecture at UNC Charlotte, as a curriculum/instructional development grant.

[2] We would like to extend our thanks to Phil Christensen, Developer of *Multi-Frame*; Stuart Feldman, Co-developer of *LightScape*, and Kevin Matthews, Developer of *DesignWorkshop*, who graciously visited our institution in March, 1998, and supported our efforts. We would also like to acknowledge the support of Mr. Paul LaVene, President of the *Carolina's Concrete Masonry Association* and their members, as well as our colleagues, Professor Charlie Mitchell, P.E., Associate Professor Chris Morgan, (retired), and Associate Professor John Nelson.

[3] We have recognized in our own teaching experience the relevance of Bloom's Taxonomy, as an aid to setting out clear expectations and exercises within the studio and lecture settings. Bloom's Taxonomy established the following objectives as fundamental educational building blocks, a. Knowledge development, b. Comprehension, c. Knowledge application, d. Analysis, e. Synthesis, and f. Evaluation/judgment. For greater elaboration, see, Benjamin S Bloom, David R. Krathwohl, and Bertram B. Masia, *Taxonomy of Educational Objectives,* (Chicago, University of Chicago Press, 1957.)