DESIGN EDUCATION: A METHODOLOGY FOR INCORPORATING COMPUTER TECHNOLOGY INTO THE DESIGN CURRICULUM

Randy H. Gimblett
Brian B. Kelley

Ball State University
College of Architecture and Planning
Muncie, Indiana 47306

ABSTRACT

Computer hardware capabilities have dramatically increased over the past ten years in terms of processing power and graphic capability. Costs have decreased to the point where educational institutions can now afford to buy such systems. Unfortunately, research exploring methods to aid educators in incorporating computer technology into the design curriculum has not kept up at the same rate. This paper examines through a comparative analysis two methodologies that integrate computer technology into the design environment. 3-Dimensional representation and abstract /volumetric form are used to explore composition as a tool to aid the designer in developing alternative design solutions. Specially designed interactive software is used to aid the student in evaluating a design by converting abstract form into realistic imagery. The results of the research indicate that the most effective way to teach students to design using computers is by reinforcing the fundamentals of design theory while introducing a palate of graphic commands. With the addition of specialized software, abstract form can be easily replaced for realistic imagery. The results of this study strongly suggest that the integration of an evolving design theory, coupled with the power of computer technology not only encourages but fosters the creative thinking process by providing the designer more opportunity to evaluate, revise and incorporate new ideas into a design, emphasizing abstract representation.

INTRODUCTION

One of the major challenges currently facing design educators today is how to effectively incorporate computer technology into the design curriculum. The design professions are currently caught in a major transition between traditional styles, philosophies and communication techniques and the technological advances in society. On one hand computer hardware capabilities have dramatically increased over the past ten years in terms of power, available memory, graphic resolution and data storage. Costs have decreased to the point where educational institutions can now afford to buy such systems.

On the other hand applied research by design educators is on the increase. Research related to the fundamentals of design theory is exploring and testing traditional design philosophies in an attempt to better understand the intuitive nature of the design process.

Technology is aiding this investigation by providing designers with the tools to systematically dissect work and synthesize vast amounts of information. The investigation and use of innovative technology is crucial to this research. Education, merging design theory with the new technology is the main cog in the wheel that will turn out a new generation of design professionals.

At Ball State University, College of Architecture and Planning we are attempting to develop tools that can be used to aid the design process. The goal of this research is to develop and test a methodology for teaching architectural design at the post-secondary level that integrates the fundamentals of design theory with computer technology.

In light of the above goal, the following research questions direct the research design:

1. Can we effectively teach design students the fundamentals of design theory using two and three-dimensional computer graphics to derive abstract /volumetric form?

2. If so, is it possible to use specialized software that aids in teaching a student to visually and methodologically evaluate and resolve design problems in abstract form rather than a preconceived design solution composed of randomly placed detailed design elements in three-dimensional space.

RESEARCH DESIGN

The research design addresses the above research questions by examining the results of a comparative analysis using two entirely different approaches to incorporating computer technology into the design studio. This study uses the power and flexibility of the Intergraph computer graphics system throughout this study. The first methodology involves reinforcing design theory as the students learn to use graphic commands and manipulate images on the Intergraph computer graphics system. The premise is that students will think more in design terms when using the computer to design rather than as a glorified drafting tool. In contrast the second methodology involves no reinforcement of design theory rather teaching students the basic functions of the computer drafting with related project work.

The first class (herein referred to as Class A) was comprised of fourth year undergraduate design students, one instructor and one graduate research assistant. There were no pre-requisites for entrance into this course. Students have been exposed to a limited amount of design theory and traditional graphic communication skills. The students had no exposure or experience on a computer graphics system. The class was to meet four times a week for a 3 hour period throughout the entire 10 week quarter. A total average of 120 hrs of studio and instruction during this time was provides. The design medium was the intergraph workstation, generic IGDS command menu and specialized software for design manipulation and evaluation.

A design vocabulary incorporating design theory was introduced to class A as they were taught the basic drawing commands on the Intergraph system. The class was introduced to 2-dimensional drawing commands and used these to create abstract compositions. After a period of 2-3 weeks 3-D drawing was introduced. In all, 5 weeks of instruction and constant reinforcing of the design vocabulary through the drawing of abstract/compositions, color theory, etc. was undertaken before the major design projects were started. The remainder of the 10 week quarter consisted of two design projects, developed using only the capability of 3-dimensional drawing.

3-Dimensional representation and abstract/volumetric form are used to explore composition and spatial relationships to aid the designer in developing alternative design solutions. Only after the design decisions have been made is the student introduced to specially developed software that converts abstract form into realistic imagery.

The second design studio (herein referred to as Class B) consisted of fourth and fifth year undergraduate design students and two instructors. The class met once a week for a 6-7 hour period for the entire 10 week quarter. In all a total average of between 60 and 70 hours of class time for the quarter was spent. The students in this design studio had been exposed to design theory in previous design studios. The only requirement for the course was that each student must have taken one of the introductory 2-Dimensional computer graphics courses offered each quarter. The premise here was that if the students had already been exposed to design theory and had certain level of experience at two-dimensional drawing then the instructors could start to teach three-dimensional drawing from day one, utilizing the advanced capabilities of 3-D drawing in the design studio.

The course consisted of approximately 7 weeks of training in 3-dimensional drawing, user command, menu generation and view control and manipulation with exercise to practice drawing commands throughout this period. The remaining weeks consisted of a design project. Both studios were closely monitored during the entire quarter. No specialized software was used during the design process to aid a student in evaluating a design.

ANALYSIS OF RESULTS

Figure #1 was the first of the projects undertaken by Class A to apply the methodology in the research. Figure #1 is an example of the abstract drawing using the commands to systematically draw each of design vocabulary. They were as follows; transition, sequence, transparency, irregularity, pattern, dispersion, concentration, contrast, dominance, order, disorder, balance, imbalance, rhythum, repetition, gradation and radiation. This exercise clearly illustrates how easily the students grasped the concept of control and manipulation of views, placing of primitive graphic elements and manipulation of this graphic elements. The students began to closely associate command selection with design terms order, disorder, circles, shapes etc. and element manipulation like copy parallel, to create order or disorder.

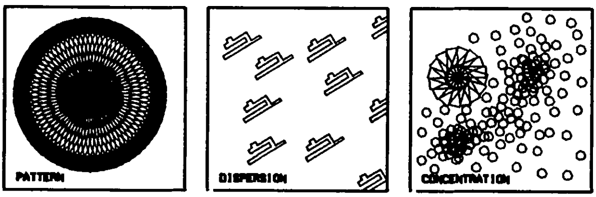


Figure #1 - Abstract Drawing of Visual Vocabulary

Figure #2 is representative of the second design exercise using four of five of design terms and commands used to draw these design terms to create a composition. The result of this exercise clearly indicates how each of the students are beginning to think more in abstract design terms with ease in manipulation of that image.

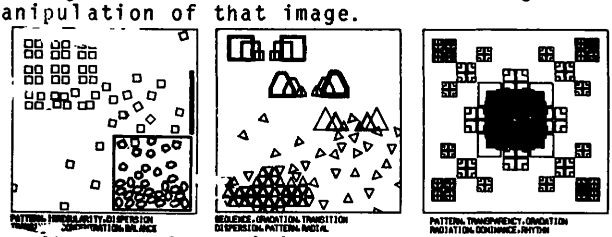
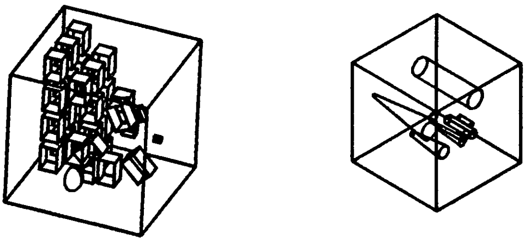


Figure #2 - Abstract Compositions

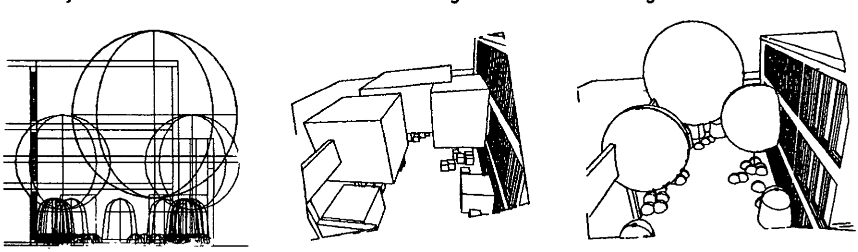
The Intergraph system is invaluable as a tool in aiding the student to envision a design in 3-dimensional space. Figures #3 & 4 reveal how easy it is to move around and design in three-dimensional space once they have learned the basics of element placement and manipulation in 2-dimensions. With the dual screens and four views on each screen, the designer can design in any of the views and reference any of the adjacent views when developing a design. Figures #3 & 4 illustrate the creation of three-dimensional abstract form within a three-dimensionally contrived space. The students quickly grasped how to manipulate 3-d views and set the active Z or three-dimensional plane while dealing within a volume. The students were able to explore the spatial relationships between abstract volumes in three-dimensional space.



Figures #3 and #4 - Three-Dimensional Abstract Compositons

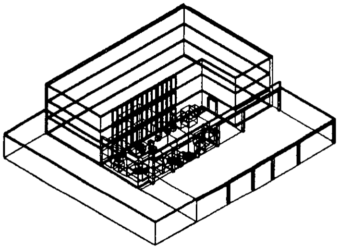
The real value of the Intergraph system for design not only lies in its ability to aid the designer in generating abstract volumes and concisely working out the interrelationships of these volumes in three-dimensional space but in its ability to aid the designer in evaluating the design in abstract form or realistic image. Evalution of the design before it was constructed or after it was designed has still been an area not well researched in design schools.

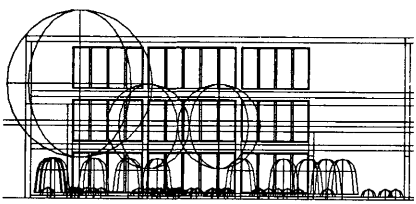
The results of this research show that the true power of the computer is its ability to visually display in three-dimensional space many alternative views of the same design. Figures #5,6 & 7 illustrate the use of the hidden line software to quickly generate various perspective views of the site by selecting the position of the viewer and the target to be viewed in any location within a cone of vision on the design plane. This provides the designer with a method to quickly evaluate and resolve any conflicts in the design early on in the design process. Further evaluation can be made later on in the design project once the abstract /volumetric relationships have been resolved by exchanging abstract volumes with detail design elements ie. details of design elements, trees, benches, facades, textures, patterns etc., to create a realistic image of the design.



Figures #5,6 & 7 - Hidden Line Perspective Views of Design

The results of this research as illustrated in figures #8 & 9 show how easily abstract design can be developed into a realistic detail design. Once the major design decisions have been made at the site scale, the designer is forced to look at design at a very detailed level. Since each volume in abstract form represents a real image that the designer envisions in the design, than it is easy from outside the design plane to divide the design into smaller detailed components. These components are created as three-dimensional cells, stored in cell libraries then by activating a user-interface replace function, each volume is quickly exchanged with the appropriate detailed cell. Any abstract form that is a closed shape and converted into a cell can be simply replaced. The detailed cell library can contain as many detailed compostions that represent a real detailed image as the designer can draw. The designer knowing for example that a volume is to represent a wall may have many styles and types of facades stored as cells and by using this replace function simply continually exchange facade for facade until the appropriate continity and image of the design the designer to trying to convey is achieved. This provides the designer with a tool to quickly evaluate the character of a design at whatever level of detail from various view points they desire.





Figures #8 & 9 - Converting Abstract Design To Real Images

Figures #10 & 11 take the evaluation of a design one step further. Figures #10 & 11 illustrate how to use a plant simulation routine to evaluate planting in a design. Figure #10 illustrates the design at the initial planting stage.

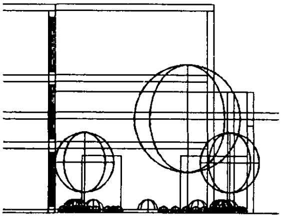


Figure #10 - Planting Plan At Time Of Planting

Figure #11 illustrates the what the design will look like 25 years down the road. The plants are grown exponentially, providing a fairly accurate representation of the degree of change that will occur over the lifetime of a project. This routine is extremely important in the evaluation of the design as a means of ensuring the character of the design is maintained or changes accordingly over a number of years.

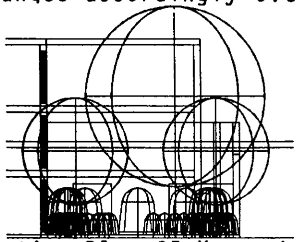
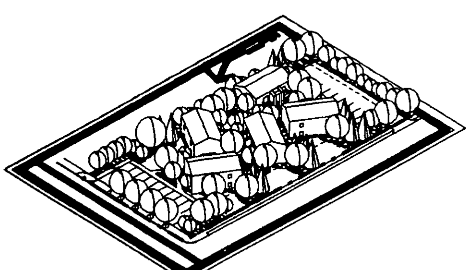


Figure #11 - Planting Plan 25 Years Later

Class B on the other hand was off to a quicker start in the design studio using three-dimensional drawing. Figure #12 illustrates a comparison of two representative examples from each class. Figure #13 were a result of two separate design projects constructed to examine three-dimensional form between weeks 6 and 7 of the quarter. A review of Figure #12 from Class A illustrates a greater amount of complexity and quality in designing in abstract volumes than in Figure #13 from Class B. The advantages that representative case Class A shown in Figure #12 has over that shown in Class B ,Figure #13 is that more time can be spent dealing with abstract design or design basics because specialized software can quickly transform these abstract ideas into realistic images. at this early stage. Volumes used in Figure #12 were developed into cells that can be replaced with real imagery. This method provides the designer with greater flexibility in evaluating a design. The designer can easily exchange these volumes as cells for a realistic image as many times as required with as many styles as there are cells to replace. The exchanging, re-evaluating and shifting of volumes around and then re-evaluating again, provides the designer with a extremely powerful design tool.



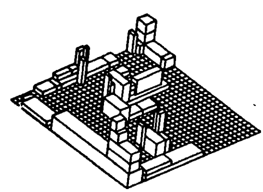


Figure #12 - Result of Class A Figure #13 - Class B

DISCUSSION AND SUMMARY

In order to truly evaluate the effectiveness of using computer technology to design or teach design one must first examine the nature of the design process in a traditional sense to determine the most suitable role computer technology plays in aiding the design process.

According to Greenberg (1984) in referring to the nature of the design process used in architectural design says that the first three phases of the design process involve problem identification, formulation of plan or strategy for approaching the problem and an attempt to create a realization or solution. Greenberg (1984,p.150) states:

> Only in the fourth stage, when there is a preliminary solution to the problem, is it possible to evaluate the results of the design. The evalutions clearly influence the next step and thus the entire design process consists of this iterative cycle, where the entry of the next iteration may be as far back in time as the initial step. Repetition through this loop is a learning process, and new ideas are continually absorbed or inserted (and perhaps later rejected) by the architect.

In light of the above discussion on the nature of the design process by reinforcing design theory through the introduction of graphic commands the designer with the aid of specialized software can spend more time developing and resolving design solutions in abstract form. This was illustrated in in Class A where the students created many more design alternatives with more freedom without getting bogged down in design detail. The student gains new perspectives of the design from re-examination and re-evaluation of the design than was the case in Class B. A Intergraph system can without a doubt speed up the first three phases of the design process as outlined by Greenberg (1984), which theoretically provides the designer with more time to design. But software like created and used in the Class A design studio used in conjunction with dynamic manipulation and various rotation commands clearly aids the designer in developing a design and evaluating throughout various stages of the process.

Having previous knowledge of computer aided drawing and without reinforcing of design theory as in Case B tends to restrict rather then enhance the design process. Students in the senior years or the design curriculum without a doubt have a preset methodology for solving design problems. This makes the transition from traditional design methods to designing with computers extremely difficult. Results of this study also indicate that without the introduction and constant reinforcing of design theory a computer tends to restrict rather then enhances creativity. This was the case in Class B were a very small palate of graphic commands and element manipulation techniques were actually used by the students out of a wide range introduced. Design theory was not the impetus reinforcing the broad range of the graphic commands. Too often the student will rely on a small range of graphic commands that they feel comfortable with, which tends to force a design solution. This serves only to restrict the design process rather then allowing the integration of computer graphics and creativity to determine how a design will evolve.

In summary, the key to the success of Class A design studio was not in teaching students how to use the basic functions of the Intergraph system nor was it in lecturing about design theory but the amalgamation of the two. The results of this study lend support to the discussion on the design process. The results of this study strongly suggest that the integration of an evolving design theory, coupled with the power of computer technology not only encourages but fosters creative thinking and learning through the evaluation process. This is due to the fact that the designer is forced to think more realistically about fundamental design issues, interactively resolve design conflicts, can explore more design alternatives with on going evaluation and re-evaluation of the design without worrying about detail. The learning process is excentuated by the continual incorporation and refining of new ideas throughout this process.

However, results also indicate that it is only after the student feels comfortable with designing on the computer that they can truely think and design creatively. Then and only then does the computer become part of the designers vocabulary which encourages them to visually and methodologically resolve and evaluate design solutions at the early stages in design development.

CONCLUSIONS

The results of this research indicate that the most effective way to teach students to design using computers is by reinforcing the fundamentals of design theory while introducing a large palate of graphic commands. With the addition of specialized software, abstract form can be easily replaced with realistic imagery. In addition this study illustrates that by incorporating the fundamentals of design theory when teaching the basics of 2 & 3-dimensional computer drawing, the design student:

A) Learns how to design by associating basic elements and element manipulations with particular components of the design theory.

B) With little or no computer experience and with minimal design training can learn a great deal about the fundamentals of design through three-dimensional volumetric /abstract form.

In addition this research illustrates that specialized software to transform volumetic form into realistic imagery without a doubt aids the student in designing and evaluating a design. Through the use of specialized software to transform abstract/volumetric design a student can spend more time in dealing with abstract form dealing more with design basics such as spatial relationships, scale etc. early on in the design process without worrying about how they are going to present their ideas, detailed design and working drawings. Too often is the case where sophisticated hand drawn graphics over weigh the design process and concealing the flaws in a design. In addition growth simlation software provides the student with a tool to quickly evaluate plant design solutions early on in the process.

The results of this research clearly indicate that students with minimal experience in design and no experience on computer can be effectively taught to design using a computer. It is important that the initial faculty to student ratio must be of approximate size as to allow a maximum of four to one student to teacher ratio. The larger the student to teacher ratio the more difficult it is to teach design using the computer.

FUTURE RESEARCH

Future research incorporating computer technology into the design curriculum should address the following issues:

1) A long range research project (over 5 years) should be initiated. This project should start in the first or second year of a students design education before they are exposed to design theory with an introductory level of graphics and follow through the entire time the students are enrolled. This would give us accurate data to properly assess how much the computer aids in the design process.

2) Plant growth simulation routines should become more sophisticated and vegetation symbols should change in form, driven by a database that will very accurately simulate growth according to climatic conditions.

3) Include in the evaluation procedures the simulation of other design components such as building facades etc.

REFERENCES

Greenberg, Donald. (1984) The coming breakthrough of computers as a true design tool. Architectural Record, September.