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3

EFFECTS OF TRADITIONAL AND DIGITAL MEDIA ON STUDENT LEARNING IN SPACE DESIGN

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Jiang Lu's chapter focuses on a hot issue in the teaching of space design – should students be trained primarily in traditional (pen and pencil) design techniques, or should their training primarily be in digital media (through such programs as AutoCAD and SketchUp)? Jiang created a set of design projects for her studio design class and gave the students wide latitude in choosing the techniques they would use. She then examined the choices they made and surveyed her students to get their perspectives on why they did what they did. Thus, one of the benefits of this chapter is that we hear the student voice, unfiltered, as they discuss their learning.

As we might imagine, choices of how to train design students are not as stark as the either/or perspective that strong advocates of either side would argue. As is often the case, Jiang concludes that rather than exploring this issue in terms of what are the right and wrong ways to do it, we need to consider whether different techniques might be most appropriate for different projects. For example, Jiang finds her students are most likely to use pen and pencil to work with re-designs of existing spaces and most likely to use 3D digital renderings for designs of new spaces. The personal preferences and skill sets of students are also factors in determining what the “correct” choice is in a given situation. I particularly appreciate this level of nuance in Jiang's arguments.

Introduction

While digital media is spreading rapidly in design education, the value of using both traditional and digital media has been the subject of heated debate among design educators (Bilda and Demirkan 2003). Radical advocates of digital media believe that the digital media should replace traditional media, while some “pencil fundamentalists” argue that traditional media should remain essential in both design education and practice. In recent years, when reviewing or revising design education curriculum, educators have been confronted with the polemics of hand versus computer, or traditional versus digital media. This controversy involves educators across all visual design-related fields: interior design, architectural design, and graphic design. For instance, educators have to make a decision as to whether manual drafting should still be taught in an interior design curriculum, when AutoCAD (Computer-Aided Design) applications have become the industry standard.

Furthermore, educators have to answer for why they still need to teach students how to draw perspectives manually, when computers can generate unlimited perspectives in real-time from a 3D model of the design. Comparative studies have been conducted to determine the superiority of either medium and the impacts of these two types of media on the design outcomes in educational settings (Gibson 2007; Meneely and Danko 2007). However, these studies had inconsistent and contradictory conclusions. This study will examine the issues concerning this debate and focus on the contextual conditions that may have decisive impacts on the outcomes of the applications of either medium. The contextual conditions primarily include the type of design problem and the students’ educational background in both media.

I have been teaching both types of media for more than seven years. It has always been a challenge to encourage or advise students to choose a specific medium for their specific space-design problems, based on their proficiency in either medium. This experience has led me to believe that this is a rather complicated case that requires a humanistic and adaptive approach in research methodology.

Literature Review

Many educators have noted the complexity of the issues regarding the roles of the traditional and digital media. Brandon (2001) pointed out that the issues are more complex than a simple mutually exclusive dichotomy. Design-related computing technology has become far more sophisticated than what a traditionalist may assume, perhaps based on his or her observations of past technology (McLain-Kark 2004). Therefore, stereotypical arguments against the so-called “computer imagery,” which was described as “very harsh, very cold, and very analytical” (Reiss 2001, 51) may be too simplistic, ignoring the many different types of digital modeling and rendering processes.

The quality of work may vary greatly depending on the authorship. In a studio, one complaint was: “everything takes longer than estimated.” Today’s academic digital design is impressive but also paradoxical (Cuff 2001). In faculty meetings, fights between digital enthusiasts and traditionalists or, in William Mitchell’s term, “pencil fundamentalists,” have been almost unavoidable (quoted in Levin 2002, 118). On the other hand, emphasis on the importance of the direct use of the hand should not be simply seen as nostalgia or cultural inertia. It may even reflect some fundamental existential meaning for designers.

It is a positive development to see that new perspectives have been suggested. For example, Dana Cuff (2001) tried to direct attention toward the profound cognitive implications of design software on architectural education. From this perspective, the computer is not a simple replacement for a designer’s pencil. It represents a very different approach to design. Dialogues between the technology and hand advocates have begun to be heard. The collaboration between MIT’s Media Lab and Haystack Mountain School of Crafts represents a new constructive relationship between the advancement of technology and the artistic tradition of humanism (Seelig 2003). A major advantage of using a digital tool to produce hand-drawn effects is the layering. This allows a designer to easily manipulate colors, textures, and design alternatives (Johnson 2001).

Over time, scholars have become increasingly aware of the potential of design and technology (D&T) as an environment for collaborative problem solving (Hennessy 1999). How to take advantage of this new technology and examine its application in traditional and

conventional fields has become a challenging study topic. For example, Meneely and Danko (2007) studied digital sketching in the creative culture of design. Their findings suggested that reflective thinking strategies should form the foundation of any technology-based design curriculum to ensure that motive, mind, and media are aligned.

In the past, I studied how to bridge the differences between digital and traditional media (Lu 2005). I found that using non-photorealistic rendering with Photoshop challenges the criticism of digital media as being very rigid and showing only a finished presentation. The non-photorealistic digital rendering as a hybrid medium is actually a medium between the extremes. Using such a medium, students can take advantage of the digital technology while enjoying individualized artistic creation. The correlation between the proficiency of students in both media indicated that the artistic principles of the traditional media are equally important in digital media. Regarding the increasing demands of digital presentations in design procedure, scholars of interior design recently discussed the digital morphology and design process. First, digital creation was more linear than the traditional method; second, cyber-ideation had a positive impact on team dynamics, and third, automated output possessed greater surface delineation when compared with subjects' manual sketching (Gibson 2007).

The majority of comparative studies have been conducted primarily from technical perspectives. Specific human experiences in the context of a design studio have not been addressed sufficiently and the proficiency of students' media applications has not been adequately examined. These experiences are informed by individual circumstances affecting students' preferences and choice of different techniques.

Therefore, it becomes crucial to examine the impact of students' individual experiences and abilities with different processes for applying different types of media in space design. Instead of trying to judge which medium is better than the other, this study examined the dynamics of students' behaviors as designers with different abilities in design media application. At the same time, it explored alternatives for using media on diverse circumstances of space design.

Process

Inspired by previous research, this study joins the effort to transcend the hand versus digital polemic by providing evidence of actual effects of the different media on the student designs and to explore the meaning of design as human experience. The research focuses on both the process and results of space design in a junior design studio during the winter of 2008. The class is a required design studio course for interior design majors. A total of 22 volunteers out of 24 students in two sections of the course participated in the study. There were 19 females and 3 males. Two students were over 30 years old and others were between 20 and 30 years old. All of the volunteers had taken CAD1 (Digital 2D Presentation) and CAD2 (Digital 3D Presentation) in our program. The two students who did not participate in the research had similar backgrounds and were between 20 and 30 years old.

In the course, students were required to use manual or digital media to complete two design projects. The participants focused on the effects of different modeling methods on the resulting space design of their projects. AutoCAD was used as the primary computer 3D modeling system since it has been part of the students' curriculum for two years. However, one student used SketchUp because she found it more intuitive and learned the software herself. As the students used these media, their learning processes involving these different design techniques were carefully observed.

A comparative approach was used in this study. Two projects were assigned during the semester. Students worked in teams of two and three, respectively, on each project. The first project was a renovation project of an existing space. This included a lobby, a board room, conference rooms, an atrium, and corridors. The second project was a cultural center in a 15,000 square foot multi-story building. These two different projects provided multiple design situations. Students had almost unlimited opportunities to apply different techniques more creatively than they would have had with a single project. Since both manual and digital techniques were used in the course, a student's proficiency in both media was compared to see if there was any correlation. Meanwhile, students compared their different experiences with themselves and others through a survey.

Students were not required to use a specific technique. They were free to select either manual or digital based upon their personal experience and motivation. Their practices were observed and analyzed to tell what they were thinking and experiencing as they applied these skills.

Beyond individual interviews, class group discussions and design team interviews were arranged several times during the semester and at the end of the semester. Questions were asked to obtain students' opinions about the approaches during the design process. The students were also asked about their experiences in applying digital 3D modeling at the beginning of space design instead of at the end of a space design for a presentation. Finally, at the end of the semester, the students filled out questionnaires about their experience, comparisons, and suggestions for applying two media in their design process.

In the SOTL seminar sponsored by the Faculty Development Center, Karen Busch, Jeff Bernstein and other colleagues in the SOTL group gave me constructive feedback and support. I modified the original hypothesis and adjusted my research methodologies during the research period. Several changes were made to the original research plan to accommodate special class situations:

1. A blog application had been considered to promote communication among students and the instructor. However, students were concerned about privacy issues. In a design studio, there is intense competition among design students or design teams. Therefore, many students were reluctant to post and share their design sketches and ideas. Based on suggestions from the students, communication among students was limited to their assigned design teams.
2. Addition of group discussions beyond individual interviews regarding research questions. In the group discussions, students inspired each other. This also provided an opportunity for the instructor to advise students on the benefits of applying 3D modeling to the process of space design.
3. Consideration of individual students' previous experience and skill. For example, students had the option to use different media instead of a uniform requirement for their final presentation, which had been arranged as a team project; the change in the

original requirements from a team presentation to individual presentations motivated every student to explore his or her specific preferences.

Results

Students were motivated when they learned that they were participating in the research, especially when they were asked to select their favorite media for the design process. Their great creativity made the results very interesting and somewhat challenging to analyze. For example, some students mixed both manual and digital media together instead of using a single media, making the data richer but also more complex in terms of analysis.

Applying 3D Modeling to the Beginning Vs. End of the Design Process

Table 3-1 shows the distribution of medium applications of using 3D modeling at the beginning and the end of the design. From the table, we can see that students' applications varied from project to project and from time to time in the design processes. It was clear that students preferred using digital media at the beginning for designing a new space. However, in the case of the renovation project, student

Table 3-1: Student Usage of 3D Modeling in Class Projects

Media	Project 1 – Existing Space			Project 2 – New Space		
	Manual	Digital	Combination	Manual	Digital	Combination
<i>Teams</i> employing 3D modeling at beginning of design (<i>n=12</i>)	7 (58%)	3 (25%)	2 (17%)	0 (0%)	8 (100%)	0 (0%)
<i>Teams</i> employing 3D modeling in project final presentation (<i>n=12</i>)	4 (33%)	5 (42%)	3 (25%)			
<i>Students</i> employing 3D modeling in project final presentation (<i>n=22</i>)				2 (9%)	7 (32%)	13 (59%)

preferences varied greatly in the beginning. By the time of the final presentation, the media application was well distributed.

Student comments on the use of digital media at the beginning of the space-creation project (project 2) are displayed, in their own words, in Table 3-2. One of the students commented:

Since this project is about such a large space, it is hard to visualize how everything will look like ... with 3D modeling at the beginning, it allows me to see the entire space and how it will look like. It helps to see it [printed out] on paper and not just in my head.

The use of 3D modeling at the beginning of the design process also improved the students' accurate understanding of the space. One student commented: "If I didn't generate the 3D modeling digitally, I thought the space was a lot bigger than it actually was." While many students found 3D modeling helpful in visualizing the large space, one student indicated that she could directly visualize the space in her mind. She

Table 3-2: Student Comments on Using Digital 3D Models at the Beginning of the "New Space" Design Process

Student	Making a Digital 3D Model
1	"Since this project is such a large space, it is hard to visualize how everything will look like.... With 3D modeling at the beginning, it allows me to see the entire space and how it will look like. It helps to see it on paper and not just in my head."
2	"If I didn't generate the 3D modeling digitally, I thought the space was a lot bigger than it actually was."
3	"I did participate in the 3D model in the beginning of the design. However, I was able to picture the space in my head as well."
4	"For a larger space, one could use 3D modeling as a way of focus on particular elements as the design changed."
5	"It gives an overall concept of the space."
6	"It is very useful to develop basics when designing [the] floor plan."
7	"Digital media creates a building shell which provides special volumes for [the] designer to fill in."
8	"Digital media creates more accurate space quickly. It may provide surprised (unexpected) spaces beyond designers' imaginations."

said: “I did participate in the 3D modeling at the beginning of the design. However, I was able to picture the space in my head as well.” This indicates that the need for digital 3D modeling varies depending on the spatial visualization ability of the students.

Another student pointed out the potential of the digital media to go beyond the designer’s imagination of the space. “Digital media creates more accurate space quickly. It may provide surprised (unexpected) spaces beyond designers’ imaginations.” From the students’ comments on the effects of using digital 3D modeling at the beginning of the design process, we can see that most of the students were positive about their experience. It helped the students to quickly visualize the space they were dealing with, especially when the space is large in scale and the design is for new construction.

Only one student did not think that 3D modeling in the beginning or during the process was helpful. “To me it is no different than looking at a floor plan.” This student was very skilled in traditional manual media, and her digital skill was not as strong as her manual skill. She used digital modeling more like an animated drawing or a whole picture instead of a still image, such as a floor plan or elevation. “I like a CAD 3D drawing because I can see more of how the space works together.”

Table 3-3 shows the results of the end-of-term survey regarding digital 3D models at the beginning of designs. All of the students believed it to be very helpful, helpful, or somewhat helpful; half chose very helpful. Of all the students, 40% chose to manipulate digital models during the design processes and all of them found the experience to be very helpful. The students that chose to manipulate digital models were all very skilled in computer 3D techniques, receiving A’s in their

Table 3-3: Using Digital 3D Models at Beginning of Design and in Design Processes (n=22)

	Not Helpful	Somewhat Helpful	Helpful	Very Helpful
Using 3D modeling at beginning of the design	0%	10%	40%	50%
Manipulating 3D digital models during design processes	0%	0%	0%	100%

digital presentation courses last semester. Only one student among the 40% indicated that she was not very good at manual sketching. Her computer skills made her feel more confident to present her work to her design team. This finding shows that students selected different media based on how proficient they were at using different media. According to students' records in the studio and grades, 95% of the students who felt that digital modeling was "very helpful" not only used digital models during their design process, but also received high grades in the course (A's and A-'s).

When asked about the advantages of applying digital 3D modeling in a space design process (see Table 3-4), one student commented, "I use CAD 3D model view in a design process. It helps to visualize the real size of the space, such as ceiling height and length of walls." Another student pointed out, "applying digital 3D modeling in a design process of space design gives me a clear idea of what the space will look like." Some students update 3D digital models to see design changes reflected in the models. "3D modeling allowed for us to see the effect on the room environment as we made changes to it." Some teams used 3D model updates as a method of team communication. "When designing and in the conceptual phases, the 3D model can really help to grasp the idea and help collaboration between team members." It is clear that continued use of 3D digital models helps students to better understand their designed space. "It helps with the planning in the brain," a student summarized.

From the interviews, team blogs, and observations in the studio teaching process, I learned that specific human experiences in the context of a design studio need to be considered when we teach. Meanwhile, the proficiency of the students' media application should be adequately examined. My experiences in this study taught me that an instructor must consider students on a case-by-case basis because they have different experiences and preferences. Instead of trying to force students to use a specific medium for their final presentation as a team, I allowed individuals to choose their own medium. This enabled me to observe the group dynamics of students' behaviors as designers with different abilities in design media application. This was a change in the original research plan to accommodate special class situations.

When examining students working on their final design presentations, I observed that the students were extremely motivated.

Table 3-4: Student Comments on Using Digital 3d Models in Design Processes

Student	Using a Digital 3D Model
1	"I use CAD 3D model view in a design process. It helps to visualize in a true size of the space, such as ceiling height and length of walls."
2	"Applying digital 3D modeling in a design process of space design gives me a clear idea of what the space will look like."
3	"During the design process 3D digital modeling helps me to visualize the space a little better, because I can see what works and what doesn't."
4	"3D modeling allowed for us to see the effect on the room environment as we made changes to it."
5	"It helps with quick ideas and conveying one's ideas to team members."
6	"We could evaluate spatial relationships within the room."
7	"I think at the beginning of the process, it is a little helpful to build a digital 3D model, until more of the design is created, I don't think it is very effective to build a model."
8	"Design changes so fast [in its development process]* that [there is] no time to change all the details in the model" [to keep all the changes].*
9	"Digital media creates consequent spaces which can visualize walking through spaces instead of a still space."

* Author's explanations

Fifty-nine percent of the students used a combination of manual and digital media to present their design work (Table 3-1). This number was higher than what I had predicted. From the final questionnaires and interviews, I learned that, to most students, there were no big differences between traditional media and digital media as some scholars have argued. Students naturally used digital media to build a basic model, for example, and then printed the image out and rendered it manually. Sometimes, they rendered a 3D model digitally first, and then used color pencils or markers to mark-up the details. How much of each medium they applied in this process varied depending on their personal preference.

Table 3-5 provides student self-reports on choosing their design medium. For example, one student commented:

I used a 3D model for the shell, but hand-rendered the digital

model when it was printed, because it looks more personal. . . . 3D (digital) modeling helps make the perspective accurate, but hand rendering allows me to add my own style.

Did the result of this mixed media application look different from using one or the other? Sometimes it did; sometimes it did not. If a rendering was printed out from a digital 3D model as a line lay-out and then printed and rendered manually, it was hard to tell whether it was initiated manually or digitally. The final result was a beautiful hand rendering. However, if a 3D model was digitally rendered, no matter how basic it was, a hand rendering could not cover all the digitally ren-

Table 3-5: Student Comments on Making Digital a 3D Model in the Final Presentation*

Student	Making a Digital 3D Model
1	“A digital 3D model helps my final presentation because sometimes it illustrates some details that I may not pay attention and ignore them before.”
2	“I used a 3D model for the shell, but hand rendered the digital modeling when it was printed, because it looks more personal. . . . 3D (digital) modeling helps make the perspective accurate, but hand rendering allows me to add my own style.”
3	“(In my final presentation*) I prefer hand sketches and rendering. I feel like I have more control.”
4	“(In my final presentation*) I feel that a hand rendering would be better because I am more comfortable with hand rendering.”
5	“Digital 3D modeling helps with gathering elements done quickly and accurately, and allows details to be added and material selections manually.”
6	“The final 3D model gives me ideas to improve my design. Mostly in special relationships and color coordination.”
7	“I am not very good at hand rendering and the 3D digital model helps me display my idea better and more realistically.”
8	“After seeing my final 3D model, I decided to drop the ceiling by 2 feet and change the placement of the sofa in the lobby area.”
9	“Digital 3D modeling and rendering give good ideas about lighting and furniture placement.”

*Note: 59% of the 22 students combined the two media in their final presentations.

dered features. Therefore both forms had advantages for designers.

I found that students' final presentations were not presentations of a final design. They were the final output accumulated through the entire design process. Their 3D models were not only processed inside their computers, but also manipulated in their minds throughout the semester. These 3D models became virtual models. The students talked about them, imagined them, and worked on them no matter how they visualized them. In addition to considering students' previous personal experience, communication among team members and peer pressure were also factors that influenced media selection for final presentations.

Designing Existing Spaces Vs. Creating New Spaces

Seven of the twelve teams (almost 60%) of students chose to use manual media to work on their design at the beginning of the design process (see Table 3-1). This occurred when they worked on an existing space where they could visually perceive what exists from photos and sketches. In contrast, when students worked on creating new spaces, they employed the digital method to generate a 3D model at the beginning of design. Interviews indicated that rapid and accurate 3D digital modeling assisted students to see their designed spaces three dimensionally. They were also able to quickly adjust their digital designs in the 3D model. According to Table 3-1, all the teams selected digital media to generate 3D models at the beginning of the design process.

There is another interesting phenomenon. From my observations, when students applied digital techniques in their designs, they used a bird's-eye-view instead of views at people's eye level. This causes some confusion in terms of estimating the height of elements and objects, such as interior walls and furniture. In addition, a bird's-eye view, without showing the ceiling, limits students' creation of the entirety of a space. Both AutoCAD and SketchUp software create 3D modeling in the form of axonometric views that show the created 3D object from above, similar to a bird's-eye view. One principle of design is that one should avoid using a bird's-eye view at the beginning of a design. In the second project, which was a new space, all the 8 teams created digital 3D models. Six teams submitted bird's-eye-view perspective drawings. Therefore, three quarters of the students were accustomed to having

a bird's-eye-view perspective when applying digital media. Since the design programs are primarily designed for architecture they are more concerned with overall massing composition which is best displayed in axonometric views.

There were five teams that updated their 3D digital models associated with their design developments throughout the entire design process. All these five teams submitted bird's-eye-view perspective drawings at the beginning of design process. This data indicate that students who created regular eye level views to review their designed spaces did not use 3D modeling to change their design during their design process. The other groups who used bird's-eye-view to view their designed spaces were more likely to adjust their 3D models during their design process. This is a very interesting finding. Average grades of each team that continued using 3D digital models were higher than those of the teams that did not continue using 3D digital models during the design process.

Conclusion

This study showed that quick digital 3D modeling helped the students understand the size and height of spaces, the proportion and scale of material applications, and especially ceiling design. With 3D modeling, students could easily manipulate complicated shapes, spaces, and components, such as stairs, open lobby spaces, curved walls and ceilings, and unique building spaces. Students worked accurately on space and furniture planning.

From their comments and from Table 3-1, we observed that students preferred to have a quick digital 3D model at the beginning of a design. However during the design process, digital modeling was favored by certain students who have better digital modeling skills or who paid more attention to spatial relations. At the end of the design process, digital 3D modeling was again popular not only for the final presentation, but also for evaluation and refinement of spatial design.

For this group of students, selecting digital or manual media depended on the space type, i.e., existing places, or created spaces. For existing spaces, student preferred manual methods, whereas for new spaces, they preferred digital modeling. As evidenced by their group blogs, using 3D models for communication among team members was

very important. Quick hand sketches were not as popular as digital 3D models. Which approach was more appropriate depended on different students' skills and preferences. Manual media showed more detailed design features than digital media. The majority of the students thought that manual media were easy to control.

As to the question of the superiority of one medium over another, there is no simple answer. It all depends on the situation – both the type of the design problem as well as the degree of proficiency in the application of the medium.

Several additional questions arise from this study. For example, how do students use 3D models to communicate with each other and to communicate with clients and instructors? How do students' prior experiences with AutoCAD and/or manual rendering influence their design decisions?

Reflection

The most rewarding experience in this study was the reflection on student learning and the impact of these reflections on my teaching during the semester. The semester was not only a learning process in space design for the students, but also a learning process of effective teaching for me. The observations and interviews in the studios provided considerable information to change my teaching to fit student needs.

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