

Rethinking Design Process: Using 3D Digital Models as an Interface in Collaborative Session

Suining Ding

Indiana University Purdue University Fort Wayne

Abstract

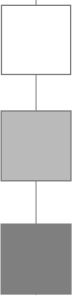
This paper describes a pilot study for an alternative design process by integrating a designer-user collaborative session with digital models. The collaborative session took place in a 3D AutoCAD class for a real world project. The 3D models served as an interface for designer-user collaboration during the design process. Students not only learned how to use 3D AutoCAD, but also experienced a collaborative session by designing a conference room. This paper also compares traditional space planning process and alternative space planning process, as well as student work and feedback from the collaborative session. Recommendations were made for future course improvements when a real world project is used in the curriculum. This paper also discusses changes in design process and the role of designers based on the collaborative session feedback.

INTRODUCTION

Many users who are seeking a design solution from designers may experience difficulties in imagining and visualizing three dimensional spaces by reading two dimensional drawings. This may lead to communication problems between designers and users. In order to solve this problem, an alternative approach to space planning was utilized by using computer generated 3D models to help users visualize three dimensional spaces. In addition to the advantage of 3D visualization, users are able to see different furniture arrangements as well as different interior finishes, such as different materials and different colors during the design process. This alternative space planning method has been integrated into a real world project-based learning process in an interior design course: CAD for Interior Design. This paper presents course design, alternative space planning process and student work, and feedback from designer-user collaborative session. In the meantime, recommendations were made for future course improvements. One of the course objectives is to let students experience a real

space planning process while using 3D AutoCAD. A real project was assigned in this course in order to achieve course objectives. Students may interact with end-users through a collaborative session where 3D models are adopted and used. The project assignment was to redesign an existing conference room and present the design concept using digital 3D models. An existing conference room is a dull and plain looking interior space without any decorative elements. During the class session, students were taken to the conference room site to verify existing conditions with measuring tapes. Photos were also taken by students during the site visit.

The requirement for this project was to create an attractive and appealing interior space with required furniture and casework. Students were asked to apply different interior finishes, such as different materials and colors to the interiors and move furniture around during a collaborative session. End users were also invited to class. Students presented different perspectives of their interior space and design concepts. Feedback on students'



presentations was very positive. The users were particularly pleased with design solutions.

The significance of this process is that it provides students with a unique opportunity to work on a real space planning project. Using 3D models, instead of 2D drawings, has solved many communication problems that often arise between designers and users during design process. Students not only learned 3D AutoCAD in design, but also went through a real space planning process with designer-user collaborative session using digital 3D models. As a result students have a better understanding of space planning and interaction with end-users. This project is also a pilot study on designer-user collaboration through use of a digital 3D model as an interface.

SPACE PLANNING PROCESS AND COLLABORATIVE SESSION

Traditional Space Planning Method and Process

Space planning is one of the major steps in schematic design. Traditional space planning method uses two-dimensional drawings to convey design concepts. Usually, designers meet with end users and present two or more alternatives. End users can express their needs and preferences through verbal communication. Once the designers obtain feedback from end users, they make changes and provide new design ideas to users during the next client meeting. However, communication problems often exist between designers and users, because some users may not be able to interpret 2D drawings and visualize a 3D space. This process can be described as following:

- Step 1: Programming. The goal of this phase is to identify user needs and preferences regarding a project as well as project objectives. The methods used in this phase are interview, questionnaire and observation. At the end of the programming phase, a written document is created. It is called a project brief or a problem statement (Pile, 2003).
- Step 2: Space Planning with Rough Sketches.

During this phase, square footage is assigned to each room. The adjacent Matrix is used for analysis of functional relationship. Bubble diagrams are used for a functional space layout. When there is more than one floor, a stacking plan is used for the layout of the functional relationship. The method used is 2D drawings.

- Step 3: After the floor plan layouts are finalized, furniture is arranged in each room. The method used is 2D drawings.
- Step 4: The last step in the space planning process is to prepare 2D drawings to show to end-users. The 2D drawings include floor plans with furniture layout.
- The traditional space planning method and process can be summarized in the following diagram (Figure 1).

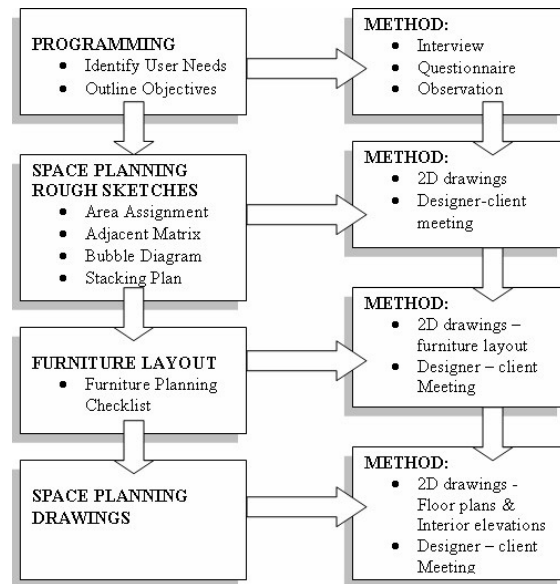


Figure 1: Traditional Space Planning Method and Process

Alternative Space Planning Method and Process

Recent research and practice have revealed that design process is changing and the design process needs to be modified. The change is from two-dimensional manual drafting to three-dimensional computer simulation and virtual reality tour. It also includes a change from expert driven model to human-centered design because designer-user

collaboration should be added as a new integrated component of the design process. It has been proven that designer's traditional ways of using two-dimensional drawings as a design media was inappropriate for new design tasks (Jones, 1992). The reason is that traditional design methods do not allow both designers and users to collaborate in the design process. Users particularly need assistance to visualize three-dimensional spaces in order to participate in the design process effectively. Therefore, a new design tool that can allow user's participation and improve user's visualization is needed. Liz Sanders, founder of MakeTools, indicates that because design tools are primarily visual, they serve as a common ground for connecting the thoughts and ideas of people from different disciplines and perspectives (Sanders, 2002). This special design tool will become a new language for both designers and users in their collaborative design. During the collaborative session of the AutoCAD class in this research, AutoCAD generates 3D models that serve as design tools and interfaces for the designer-user collaboration in design process.

The alternative space planning method is integrated into this AutoCAD course, since many end-users had experienced difficulties in visualizing a three dimensional space by reading two-dimensional drawings. Therefore, computer generated 3D models are utilized as a design tool to ensure good communication between designers and users. Users can understand designers' intent better, so it enhances collaboration between designers and end-users. In addition to this advantage, users are able to see different furniture arrangements, as well as different interior finishes during this process. Major changes in this alternative approach can be summarized and described as following:

- Step 1 : Programming – No change
- Step 2 : Space Planning Rough Sketches – No Change
- Step 3: Furniture Layout – During this phase, the alternative method is to create 3D models of furniture. The furniture can be moved by both designers and users. The meeting is no

longer a designer-centered meeting. Instead, it is a user-designer collaborative session.

- Step 4: Space Planning Drawings – The alternative method used during this phase is to build 3D models of interior space. Interior materials, colors and lighting designs can be changed at any time. It also provides different perspectives for end-users. The meeting actually is a designer-user collaborative session.

Figure 2 outlines the changes in traditional space planning method and process.

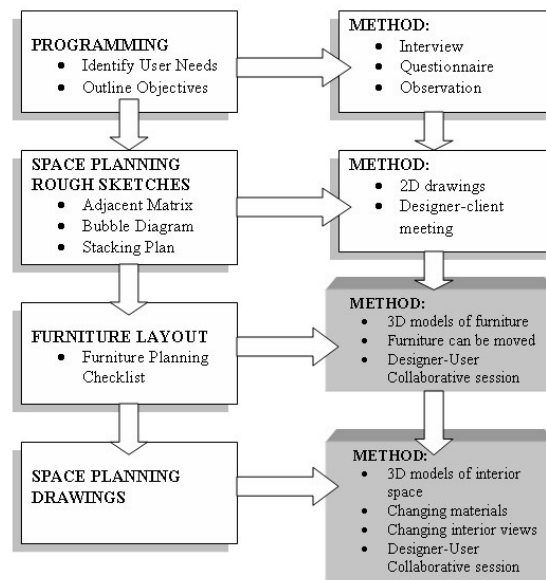


Figure 2: Alternative Space Planning Method and Process

Designer-User Collaborative Session in the Design Field

Collaborative design session is not any new concept in design process. The concept of collaborative design has been introduced in several fields, such as architectural design and product design (Ehn, 1998; Granath, Lindahl, & Rehal, 1996; Horgen, Joroff, Porter, & Schon, 1999). The tools used in the collaborative session are diverse ranging from computer-based tool to bits of plastic foam, as well as other forms of physical tools. Johansson et al (2002) held a collaborative design lab to engage multi-disciplinary partners, such as users, external partners and designers to design an experimental office. In the collaborative design lab, participants

used various tools and design artifacts, such as video cards, board games, scenarios and interactive digital VR visualizations, which were developed with the purpose of promoting creativity and facilitating common understanding of the design problem. One of these tools was a visualization tool developed using ForeSite Designer in Johansson's workshop. ForeSite Designer had an interface for placing and spatially organizing geometrical elements on a 2D surface (Johansson, Frost, Brandt, Binder, and Messester, 2002). It is clear that a computer-based design tool in a collaborative design session has been explored by previous studies. However, participants' reaction to computer-based design tools, such as a digital 3D model, has not been studied and tested for space planning yet. Therefore, it is important to conduct a pilot study in order to get feedback of participants in a collaborative session.

In addition, a number of architects have attempted to involve eventual users in the design process. Among these experiments, Lucien Kroll's medical faculty buildings at the University of Louvain, Belgium are a notable project (Pile, 2003). Kroll and his design team substantially involved the community in design decisions. Students were divided into flexible teams and participated in designing the buildings. They shifted small bits of plastic foam around to work out the overall model. When any disagreement occurred, or one group became too fixed, Kroll reorganized the teams so that each one became familiar with another's problems. Kroll would not draw up the plans and sections until a possible solution was generated (Mitchell, 1993). Clearly, Kroll changed the design process from a simple consultation to an active participation. To search for an alternative solution to traditional design approaches, Kroll recognized the need and importance of user participation in design and introduced his modular modeling system to enable users to become involved in the design process. In this case, small bits of plastic foam are the design tool that was used in the participatory design.

Furthermore, additional literature review reveals that collaborative design sessions have been

explored in product design, web design and other design disciplines with different types of design tools. Therefore, using three dimensional design tools is an effective way to aid users in participation in a collaborative session during a design process.

Computer Aided Design Tool in the Design Process

Previous research and practice have shown that users need 3-dimensional models to help them participate in the design process in order to imagine three-dimensional spaces and objects. Two-dimensional graphical representations like plans and sections are only partial views of spatial environments. To make these views as consistent and complete with real spatial environments as possible, designers could use digital 3D models. To make a 3D model, designers usually extend graphic 2D elements into the third dimension. This allows models presented in three-dimensional form to be rotated.

New technology also leads to innovative visualization tools for the design process. For example, VR is being used to create virtual prototypes in which designers and others can immerse themselves. Once again, the trend toward earlier and rougher prototypes can be seen in the virtual domain (Sanders, 2005). Researchers are finding that low-tech tools such as video can be used to create very rough and immersive 3-D like environments that are very useful early in the design process (Keller & Stappers, 2001).

In England, Robert Aish has been experimenting with a revolutionary approach to a CAD (Computer-Aided-Design) system that is called "Intelligent Building Blocks." It was developed so that users could construct models of what they want in architecture. He has found that users understand models much better than they understand architectural drawings (Kleeman, 1991).

CAD is an effective software application that is widely used in architectural design and the interior design field today. Most CAD systems allow designers to present perspective or isometric

views of 3-D objects with colorful shading. They have been adopted widely as useful tools for speeding up and improving the design process. Some designers have tried to use CAD models in early design phases (McCullough, 1990). CAD can be used to allow users to move and arrange furniture and change materials and lighting designs and can also present 3-D perspective views. Using CAD is an effective method to shape design creation because it can generate shapes and forms beyond the designer's ability. The use of models in the design process may become very important because it has the capability to allow users to understand three dimensional forms and spatial relationships when users participate in the design process. These powerful capabilities of CAD make it very useful in the design field. The information from these literature reviews provides the rationale for the pilot study that was conducted in this CAD class.

Course Design

The course is offered to second year interior design students to teach them advanced AutoCAD skills. The first course objective is for students to learn how to use AutoCAD software and build 3D models. The second course objective is to let students experience a real space planning process and interact with end-users through a collaborative session. Communication problems are expected to be solved during the design process when designer interacts with end-users through computer generated three dimensional models. The third course objective is to get feedback via the collaborative session, which is a pilot study of using 3D digital models as an interface. One aspect of a successful learning process is to assess different perspectives so that students become knowledgeable through dialogue and interaction with end-users, peers and design professionals. In order to assess learning outcomes and application of knowledge and skills that students have learned from this course, a comprehensive final project is required in this course. It is also mandatory to participate in the collaborative session and present design concept with digital 3D models. The final project is to re-design a real conference room which is plain and without many decorations (Figure 3 and Figure 4).

Students need to go through a real space planning process and get feedback from end users. Details of this final project process can be described as following:

- Step 1: Project assignment - The project descriptions and requirements, as well as the existing conditions shown on the dimensional floor plan and section were given to students.
- Step 2: Field measurement and site visit – Students were taken to the conference room to see the existing conditions and took photos or measurements as necessary.
- Step 3: Studio Time – Students spent two and a half weeks in class building 3D models of the conference room interior space with 3D models of furniture and lighting design. The instructor provided assistance and advice to students. During this period, the instructor's role varied, ranging from a co-designer to a coach.
- Step 4: Designer/User Collaboration Session - End users were invited to the class. Students presented their design solutions with different perspectives and receive feedback from the end users.



Figure 3: *Photo of Existing Conference Room*

Project Requirement

The main goal of this project was to create an attractive and appealing interior space which was

furnished with a teleconference screen; a refreshments counter; a display case for trophies; a conference table with at least four chairs. Students' creativity was stimulated by the instructor. Possible architectural components such as coffer ceilings, coved ceilings or dome ceilings with different lighting designs were shown to students. Students were required to apply different interior finishes to the interiors and move the furniture around when presenting their design concepts to users. The photos (Figure 3 and Figure 4) show the existing conditions of the conference room. There was no display case in the room. All trophies and certificates were displayed on a simple shelf. The ceiling was ordinary acoustical ceiling tiles. The interior lighting and wall paint were very plain. The color tone in the conference room was cool gray.



Figure 4: *Photo of Existing Conference Room*

The design requirements for this conference room included:

1. A conference table with at least six chairs
2. A countertop for serving refreshment and drinks
3. A display case (glass window / display window)
4. A screen for Tele-conference
5. A ceiling that can be a dome, a curved ceiling; a coffer ceiling; a floating ceiling or any other type of ceiling.
6. A 3D rendering for this space with different

perspectives by using 3D AutoCAD.

7. Appropriate interior finishes for this interior space and design lighting for this room.

Designer - User Collaboration Session

The end users were invited to the class. Students were required to present their design solutions to the users. Students had to present different perspective views and explain their design intents. The 3D models provided impressive visual images to users. Users asked questions and made suggestions to students. The feedback was very positive. Users were very pleased with the design solutions. Users stated that students' designs had exceeded their expectations. The users enjoyed the collaborative session with the 3D models. The final 3D models of the conference room not only allowed designers to change the materials for furniture and interior finishes, but also allowed designers to move the furniture around. The 3D models provided the designers much freedom in the design process. In the meantime, they solved the communication problems that had existed between designers and users. Students greatly benefited from this designer-user interaction learning process. They experienced a real space planning process with 3D models. Students stated in their course evaluations "I enjoyed making 3D models and I feel so proud of myself and being able to present design concepts to users...."

Figure 5 and Figure 6 show a sample of a student work from this class. This sample design provides a warm color tone in the conference room. A glass display case adds a sense of sophistication to the space. A coffered ceiling adds more visual interests. A refreshment counter is provided. Lighting design and art accessories help to achieve the goal of an attractive and appealing space.

The following highlights the feedback from end-users who participated in the collaborative session:

"It would be more flexible if there are more pre-made furniture in the CAD system. So that

I could choose different type of furniture in the design process...”

“I like the flexibility of changing materials and colors of interior space in the design process. It provides visual images of the design. However, if the system could provide virtual reality tour in the space, it would add more value to the collaborative session...”

“I have no experience of using any CAD software. I would appreciate if a brief training of using CAD was given at the beginning of the collaborative session. I would get more involved in the design process...”

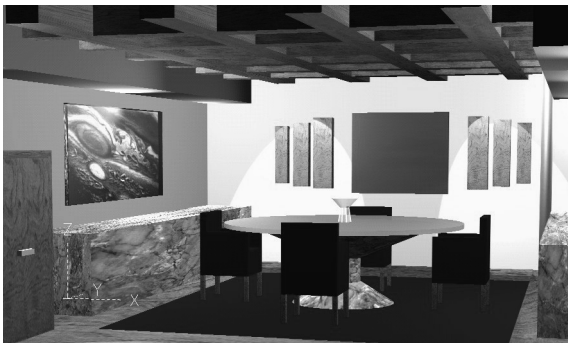


Figure 5: Sample of Student Work - 3D Model of Redesigned Conference Room

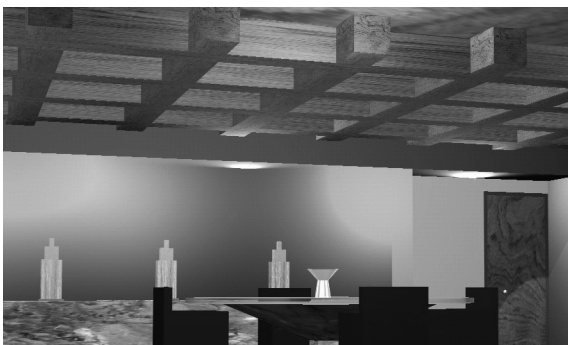


Figure 6: Sample of Student Work – 3D model of Redesigned Conference Room

SUMMARY

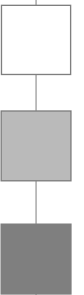
Recommendations for Future Course Improvement

Research indicates that a successful learning process involves an interaction among students, instructors, and others professionals. Real world project-based learning requires effective communication and interaction. Furthermore, getting students involved in real-world projects and linking new information to prior knowledge requires effective communication and collaboration among instructors, students, and others. Student-instructor collaboration is not the only component; instead there are other collaborations in the classroom such as student and end-user collaboration. Therefore, integrating a real world project-based learning component into this AutoCAD course requires an effective communication method that can ensure successful interactions between students and users. It is obvious that computer generated 3D models will be one of the key tools to achieve the success of collaborations in design process.

The alternative space planning process through 3D visualization significantly involves users in the design process. The significance of this process is that users have a say in the process and are able to act as decision makers. Because of this real world project-based learning component, students not only have learned 3D AutoCAD, but also have gone through an alternative space planning process which integrates a collaborative session with 3D models. As a result students have a better understanding of the space planning and interaction with users. A limitation to this approach is limited choice of 3D furniture models and caseworks. A future study direction can be creation of a furniture library in order to provide more choices to users. Real world project learning may help the students relate to the real world because it addresses real world issues that are relevant to students’ lives or communities.

Recommendations for future course improvement are:

- To keep real-world project-based learning com-



ponent in the course design.

- To use digital 3D models as an interface in the collaborative session because it is an effective way to aid end-users participating in the design process. Future digital models could allow a virtual tour of the interior space instead of a static view of the space for the collaborative session. Therefore, 3D Studio Max could be introduced in class. The digital models created by AutoCAD can be imported into 3D Studio Max so that users can walk through the interior space.
- To include design reviews as a short structured event, in which a group of people discusses the work they have done so far, and their plans to complete the project. Design reviews throughout the project give students the chance to learn from each other and learn how to critique constructively. This method allows peers to critique the plan and offer suggestions. Students can learn a lot from each other.
- To add more designer-user collaborative sessions throughout the semester so that students may get feedbacks from users in the early stages of the design process.
- To maintain effective communication and collaboration essential to achieve a successful learning process. The professor needs to switch roles from an instructor to a facilitator or helper when students interact with end-users.

Design Process is Changing

Feedback from the collaborative session supports the concept of integration of computer-based collaborative sessions in the design process. Using computer-based design tools to aid user participatory design results in two significant changes to the traditional design process: in the areas of design method and designer's role.

Change in the design method

In traditional design process, the design method is "design by drawing," which is two-dimensional and is created only by the designer. However, the use of computer-based design tools not only al-

lows designers to create three-dimensional forms, but also allows end-users to effectively participate in the design process with visual 3D models. The computer-based design tool makes entire design process visible to end-users.

Change in the designer's role

Integrating the collaborative sessions into the traditional design process changes the designer's role. In the traditional design process, the designer is the primary person generating the final design solution. The idea usually comes from the designer's perspective. However, during the designer-user collaborative session, the designer actually plays a role of a facilitator or a coordinator. The main idea comes from users with the help of the designer. The designer provides their suggestions and aids to users in the design process. The focus is on the user's ideas and perceptions in the whole session. The roles of designer and user are becoming mutually interdependent. Designers will participate in the creation of computer-based design tools. Designers will be responsible for the analysis and interpretation of the ideas that the user generated. Finally, designers will be able to use the ideas generated by the users as sources of design inspiration and innovation.

In conclusion, integrating a collaborative session with digital 3D models as an interface is a successful learning process for the students. The student-user collaborative session is an important component in this class. Students have gained a unique design experience that they would not have obtained from a traditional class. More importantly, it will eventually help students to get prepared for their future professional practice. This collaborative session is a pilot study of using digital 3D models as an interface to solve communication problems between the designers and the users. Feedback confirmed that the alternative design process is a very effective approach. However, more studies still need to be done regarding users' perception in the virtual 3D environment. Additional testing of collaborative sessions needs to be conducted through a variety of projects. The future research project may also include distributing a questionnaire after the collaborative session

in order to collect quantitative data from users to be analyzed by statistical methods. Research in the future will focus on the user perceptions of the 3D virtual environment. The scientific findings will provide valuable additions to the body of knowledge of computer aided design.

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