AC 2009-646: AN APPROACH TO SELECTING EFFECTIVE PROJECTS FOR ENGINEERING COMPUTER GRAPHICS

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An Approach to Select Effective Projects for Engineering Computer Graphics

Abstract

Engineering Computer Aided Graphics (known as AutoCAD) has been offered at Florida Gulf Coast University (FGCU) for approximately 2-½ years to an average of 30 junior Civil and Environmental Engineering students per semester. At FGCU, as well as at many other universities across the nation, this two-credit hour course is usually structured into two 1-¼ hour sessions per week. The major problem faced herein is that this is not sufficient time in which to effectively cover course materials. Selection of the design project has become crucial to maximizing the student learning outcomes. The instructor challenges the students by selecting a design project with real life parameters; in this case, the new buildings being constructed on campus. Students are provided with only a text file of the proposed plan of one of the future campus buildings. Students are divided into groups of two to four and required to use their combined imaginations and engineering abilities to produce a design that meets the minimum expectations outlined by the instructor. On the last day of class, students showcase their final designs in a poster presentation. Grades are assigned by invited guests. Surveys, feedback from the judges, and performance by the students have demonstrated that this approach is very effective in improving a student's learning outcome, ability to work with others, design ability, and communication skills. Other schools could also use such an approach to increase student participation and to improve student learning in engineering computer graphics courses.

Introduction

The challenge of maximizing student classroom learning within minimal time constraints is a very real one for the educator. Nowhere is this problem more apparent that in the field of Engineering Computer Aided Graphics (AutoCAD). The following is the study plan I have successfully used to maximize student learning by placing it in a real life context. Established in 1997, FGCU is the newest public university in the State of Florida and, as such, attracts thousands of new freshmen each year because of its commitment to academic excellence combined with a growing, younger regional population. The U.A. Whitaker School of Engineering (WSOE), which first admitted students in 2006, offers three Bachelor of Science degrees: Bioengineering, Civil Engineering, and Environmental Engineering. The teaching mission of FGCU and the U.A. Whitaker School of Engineering is to foster excellence in teaching by incorporating innovation through the integration of lectures and labs in all the engineering classes. The "lab exercise" is embedded into the lecture. Additional information about this technique is provided by O'Neil[1] and Villiers[2].

Engineering Computer Graphics has been offered in the program since spring 2007. The average class size is 30. The course objectives are to introduce the students to both basic and advanced commands; to create two-dimensional (2-D) and three-dimensional (3-D) drawings using AutoCAD software; to create scaled and full-size drawings that adhere to proper conventions for line types, symbols, legends, text lettering and abbreviations, margin settings, and detailing; and to develop effective presentation and writing skills. The challenge is to meet all of the above mentioned objectives within the very limited two 1-¼ hour sessions (two-credit course) per week.

The ability to use the techniques, skills, and modern engineering tools necessary for civil and environmental engineering practice are all requirements of the Accreditation Board for Engineering and Technology (ABET) [3]. ABET also requires effective communication skills for undergraduate students. There are not unique ways to identify engineering talents/abilities in student learning. Oftentimes, outside of academia, potential performance super stars are identified by allowing contestants to sing a song; for example, on The American Idol reality TV show. The judges and the general public (by virtual voting) identify the person with the best talent. Many of these young performers find success, live their dreams, and gain acceptance from both from the music industry and the general public. Can similar models be used just as effectively in the field of education?

As mentioned by T.J. Branoff, an engineering computer aided graphics course is an excellent means to introduce students to design processes[4]. Conducting team projects often increases the quality of classroom life and facilitates student learning[5]. Many AutoCAD faculties allow students to reproduce an exciting drawing to evaluate their design capabilities. The author of this paper has used this approach in many other engineering courses which also requires a final project. In lieu of this more conventional approach, a text file of the proposed plans for one of the future buildings on the FGCU campus was provided by this instructor to the students. Each team selected a theme, identified relevant AutoCAD commands needed to execute the project, determined how to evaluate the effectiveness of the final project, formulated a conclusion, and prepared a design. The belief is that the students are better prepared to use their imaginations and engineering abilities to produce a design that meets the minimum expectations outlined by the instructor. The author is aware that this approach is not unique. However, what is unique is the creativity used by the instructor to evaluate the effectiveness of this approach and to demonstrate improved student learning. This statement is supported by surveys and feedback from both students and judges during the semester.

Methodology

On the first week of class, a survey was conducted to identify each student's background and prior knowledge about AutoCAD. In addition, students were required to reproduce a 2-dimensional drawing within 45 minutes. This exercise was undertaken to assess each individual student's existing knowledge of drawing objects and ability to use advanced commands to add text and dimensions to drawings. Information gathered from the survey was instrumental in allowing the instructor to assess the dynamics of the students and thereby present lecture materials in the most effective way possible. The class was structured into three (3) distinct phases. During the first phase, the students were expected to draw and modify any basic 2-D drawings using commands such as lines, circles, trim, and fillet. In the second phase, more emphasis was given to details such as text, dimension, and hatching. In the last phase, the students were introduced to 3-D modeling. These topics are typical of AutoCAD courses in different institutions[4].

Normally, the final project was introduced to students near the end of the second phase. Most AutoCAD instructors expect students to reproduce an existing drawing. However, the author felt that this aspect of the course is well utilized through various tests, quizzes, and homework. Instead, the university architect was invited as a guest speaker to introduce and talk about the expectations and requirements of the final project. The text file of the proposed plan of one of the

future building on campus was at this point provided to the students who used their combined imaginations and engineering abilities to produce a potential masterpiece.

On the last day of class, the students showcased their work to the judges which included faculty from the WSOE, university Architect, and other engineers in the area. A survey was conducted to determine both the students' and judges' perspective on the class. Throughout the semester, surveys were also conducted to assess the students' learning, instructor performance level, and effectiveness of the final project.

Grading and Policy

Homework was assigned periodically and weighted 15% of the total grade. Several pop quizzes throughout the semester counted for 10%. Three tests (one for each phase) counted 50%. The final project counted for 25%. No make-up quizzes and tests were given without prior authorization or being in accordance with the university policy. It was mandatory that students were present during the presentation unless the absence was approved by the instructor in advance.

Analysis and Results

As previously mentioned, during the first week of each semester a survey was given to each student to identify prior knowledge of AutoCAD. As can be seen in Figure 1, only a small percentage of students were well experienced with AutoCAD. On an average, about 35% of the students used AutoCAD either in high school or at the local community college. After several semesters, it became apparent that more and more students were taking AutoCAD for the first time without prior experience. This was largely a result of the AutoCAD phase being eliminated as a pre-requisite for the Engineering Concepts and Methods course, in which students were introduced to engineering problem solving and design method. After the spring of 2007, the AutoCAD phase was viewed as redundant in this course. Regardless of their past experience, all students performed equally well and benefited from the knowledge gained in the course. Similar observations were made by Fentiman[6].

As previously mentioned, pop quizzes were given throughout the semester. At the end of each phase, a 1 hour and 15 minute test was given to all the students. Figure 2 represents typical drawings per test. On the first test, the instructor's objective was to identify the student's ability to reproduce basic drawings using basic drawing setup and commands from the "Draw and Modify" menu. The second test was normally more challenging and required more details such as dimensions, text, and hatching, which must be completed within a short time period (1-¼ hour). The instructor hoped to give the students a sense of reality by challenging them with a complex drawing in which only those who approached the problem wisely and selected advanced commands would complete the test on time. Even though the final is cumulative, 75% to 80% of tests included concepts and commands to reproduce 3-dimensional drawings.

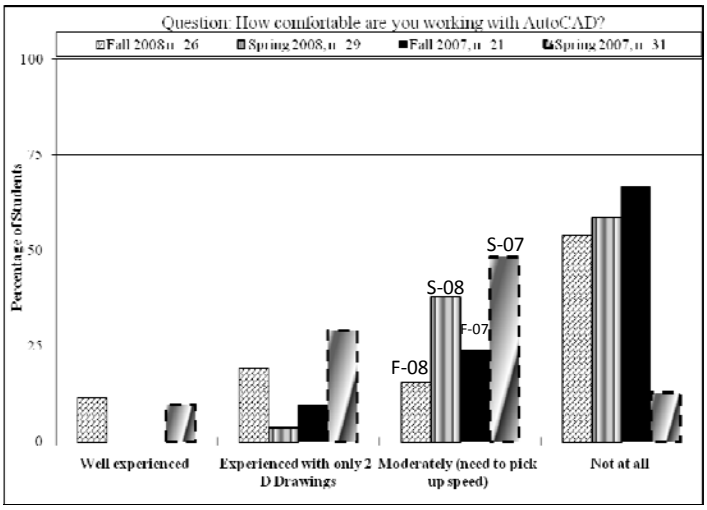

Figure 1. Percentage of students' experience with AutoCAD prior to this course

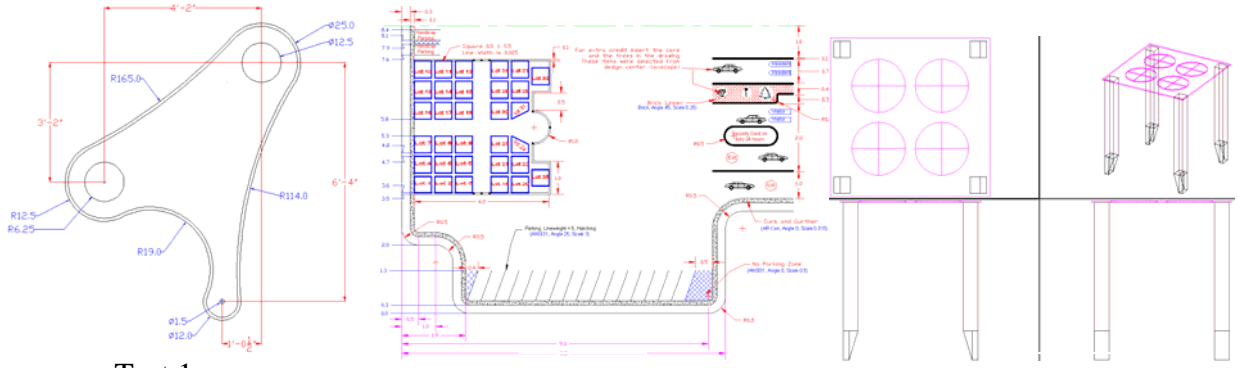

Figure 2. Average drawings per test

I. Assessment of Project Approach

The term project was presented to students at the end of the second phase of the course. At this point, the students were well experienced in reproducing any 2-Dimensional shape drawings with details including text and dimensions. The school architect was invited as a guest speaker and introduced the project to the students. For the last 2-½ years, a text file of the proposed plan for future buildings on campus has been provided. At a minimum, the students were required to produce a 2-dimensional AutoCAD drawing of the front elevation of the building. They were not restricted to cost, shape, and style. The students, therefore, took the opportunity and used their creativity to produce designs that were beyond the instructor's expectations. Selected projects from the last semesters are presented in Figures 3 to 5. Many other projects could have been selected, as the majority are of very high quality. All the teams have to make up a name (example, GTKL Engineering, Remain Standing Inc.) for their respective firms. All the drawings were made using AutoCAD 2007.

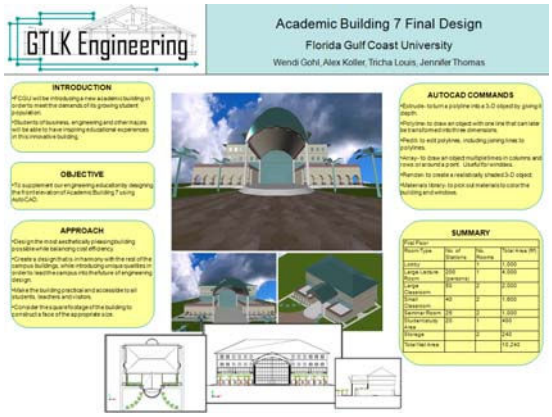

Figure 3. Selected Project from "GTLK Engineering Group" (Spring 2007 student poster presentation)

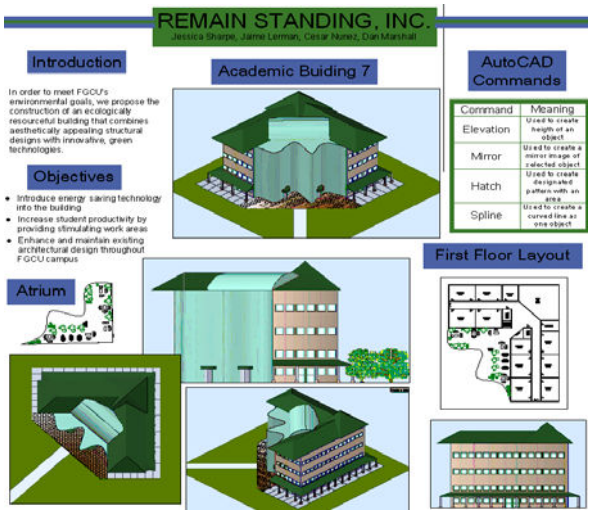

Figure 4. Selected Project from "Remain Standing, Inc" (Fall 2007 student poster presentation)

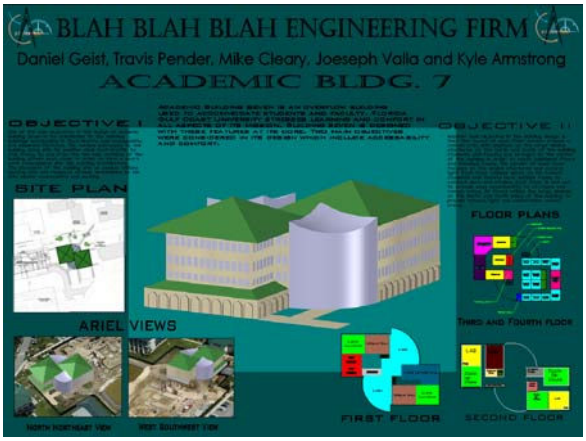

Figure 5. Selected project from "BLAH Engineering Firm" (Spring 2008 student poster presentation)

Recall that two dimensional drawing was the minimum requirement from the instructor for the final project. Three dimensional drawing was not taught extensively in this course. Over 90% of the students used 3-D in their drawings. For the final project, students used concepts such as "extrude", "surface generation", and "render" that were introduced to them for only for a brief period and also used commands and concepts that were never presented in the classroom (due to time constraints). For example, the students on the first poster presentation (Figure 3) used the materials library on AutoCAD to pick a background (blue sky) and to add the tiles/bricks in front of their building. The students in the second project (Figure 4) used AutoCAD entirely (drawing and poster presentation layout and design) in their final project. These students used green technology as their main theme. That is demonstrated by the selection of color on the roof and perimeter of their design. In the third project (Figure 5), the students also made extensive use of AutoCAD 3-D to make their poster. In addition, they used aerial photography to orient and place their building at the location where they envisioned it would be constructed. From the day the project was introduced to the day of the actual presentation, the instructor allocated 5 to 10 minutes of classroom time for progress updates. In addition, in the week before the final presentation, students practiced a trial version of the final presentations. This exercise gave the students a chance to practice in front of an audience. They also received comments and feedback from their peers and the instructor. This exercise further advanced their knowledge of materials presented in the classroom because each group had to explain and share with classmates, its respective approach, logic, theme, and advanced commands used for the final project. On the last day of the semester, the students dressed professionally and showcased their final products in front of the invited guests in a poster presentation setting.

II. Assessment of Project Effectiveness

During the last two semesters, a survey questionnaire designed to study the effectiveness of the approach was used by the instructor to design the end-of-the-semester project. These results are presented in Figure 6. Both the students and judges overwhelmingly supported keeping the proposed approach of the final project. As seen in Figure 6, 94 - 100% of the students agreed with the statement that the project was very effective in improving their learning outcome, ability to work with others, design ability, and communication skills. The judges strongly agreed (over 93%) with the project goals. Unfortunately, no record was available from the previous semesters. However, the students and judges both verbally stated that this project advanced their thinking abilities. More data will be available at the end of this semester. This semester, students were given the option of reproducing an existing drawing from one of the existing blueprints on campus. It is a fairly large drawing with a large amount of details. However, students would not have to think outside the box because everything would be provided for them. Surprisingly, only one group volunteered to pursue this idea.

In the comments sections of the survey, many students wrote that they liked the project approach because it encouraged and developed their creativity. One student wrote "great real world experience! Coming up with their own plans make them think more about the design process and creative thinking." The judges shared the same common thoughts. They recommended keeping the same project approach. "Open-ended" added one judge "encourages problem solving ability." However, a few students had concerns. One student reported "by putting too much emphasis on actual presenting rather than AutoCAD work itself may not be a good idea. Incorporate a couple of floor plans." This student recommended "make it based more on AutoCAD rather than the actual building." These comments are very valuable in improving the

quality of the course. Modifications will be made to provide course materials in such a way to better stimulate student enthusiasm which, in turn, results in increased student learning.

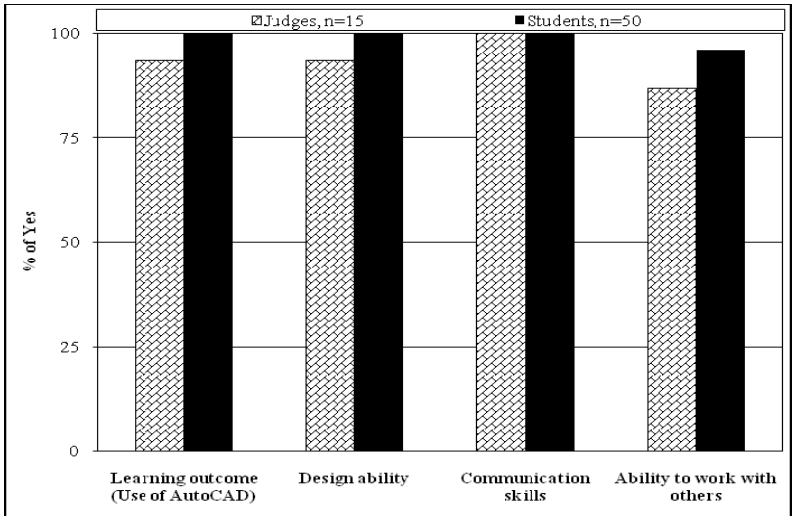

Figure 6. Students experience with AutoCAD after this course

III. Learning Level and Instructor Performance Rating

Teaching quality is difficult to measure quantitatively. In an attempt to measure that, student surveys were taken throughout the semester (at least mid- and end-of-the-semester). Many of the judges reported improvement in quality on the students' posters over time. In addition, the FGCU online survey was filled out by the students. The results are presented in Figure 7. Since it is the official evaluation, the online survey will be selected to assess the student learning level along with the instructor's rating. The instructor performance was rated high (about 4.5 on a scale of 5), especially in the first semester. Based on the information reported by the students, they learned a great deal based on the materials that were presented in this course. There was a decrease on the students' learning and faculty performance in the second semester. Although the rating remains high (4.0 on a scale of 5), the instructor is concerned and appropriate measurements are in place to address this issue. It is hard to identify the true causes; however, next semester, more in-class activities will be conducted and homework, quizzes, and tests will be returned to the students in a more timely fashion.

In the comments sections of the survey, many students concluded that "Dr. Villiers is a great teacher who knows and understands the materials very well. His personality is great for interactive learning and overall he is a nice guy." Others mentioned that the class was very well designed and that they really enjoyed the subject matter and learned a great deal. One student wrote "Dr. Villiers was there to help and assist anyone if they had a problem with the subject. He is a teacher that wants the students to succeed and do well and represent the school after they graduate. He is a great teacher, excellent role model, and every student should take a class with him and get to know him." However, a few of them expressed concern with the time allocated to teach the course. For example, some have mentioned that "Dr. Villiers is an excellent teacher. I only wished that we had more time in the class for projects."

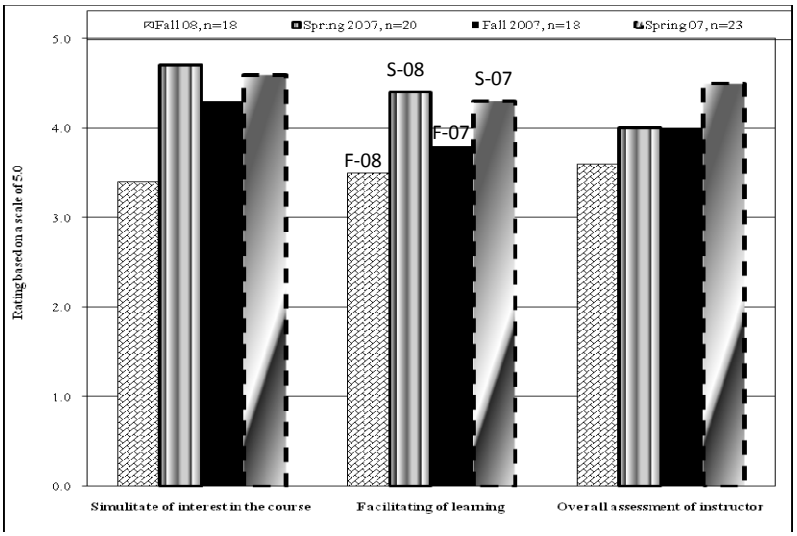

Figure **7**. Assessment of student learning level and instructor's performance rating

Summary

The selection of an existing blueprint as a final project for AutoCAD can be well structured to advance student knowledge about the subject matter. Data gathered for the past 2-½ years showed that both the students and judges overwhelmingly supported the way the final project was structured in this class and gave students the opportunity to think outside the box. Students were free to use their imagination and engineering judgment to produce a masterpiece building based on a common theme of choice (example, green technology). Although encouraged to keep the architectural harmony and context congruent with the surrounding campus buildings, students were not restricted by cost, shape, or from the use of any other innovative ideas. For the past 2-½ years, students enrolled in the course have produced a final product well beyond the minimum expectations. They have used concepts and AutoCAD commands that were never introduced in class due to time limits. This is one addition that kept the student learning to a maximum. The benefits of exposing these students to real life projects have proven to be much more beneficial than anticipated. Many students felt confident enough in their own abilities to secure internships dealing with AutoCAD over the summer semester. Plans are underway to compete for the first time in the Mystery (CAD) competition at the 2009 ASCE Southeast Student Conference, March 26-28, 2009. Continued monitoring of the data may be used to assess improved student learning and perhaps enrollment growth in the program. Data gathered can also be used to assess the "G" and "K" outcomes (effective communicate and use of modern engineering tools) from the ABET criteria. Other schools can also use this approach to increase student participation and improve student learning in engineering computer graphics courses.

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Competition. This is a milestone for our growing Engineering program in the U.A. Whitaker School of Engineering.

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