SESSION 3438

Comparing Different Teaching Models in a First Year Computer Aided Design Course

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Introduction

All engineering students at Rensselaer Polytechnic Institute are required to take a one-credit course in solid modeling. This course, Engineering Graphics and Computer Aided Design (EG&CAD) teaches the skills of using a solid modeling system to create parts, small assemblies, and documentation. More importantly, EG&CAD also emphasizes the use of vectors in creating solid models and thereby provides students reinforcement of their linear algebra knowledge. The students normally take EG&CAD during their first year and then have the opportunity to use solid modeling in their sophomore and senior design projects as well as some special topic electives. In addition, several other courses are now using solid models as a way to demonstrate fundamental principles[2]. With an increasing dependence on solid modeling skills required, it is imperative that the course content in EG&CAD be effectively delivered and evaluated.

EG&CAD runs twelve to twenty sections each semester; concerns about equality of instruction and evaluation between the sections always existed. Over the last ten years, several methods of instruction and teaching material have been developed to help ensure the uniformity of the learning experience for the students[4][5][6][8]. Given the large size of the course, care has always been taken in introducing new teaching methods. Normally, a new method or new material is introduced in the Spring semester with the course coordinator as the instructor. If successful, a second trial is held during the summer sessions as the summer sessions will introduce the software version used for the next academic year. Given that both trials are successful, all sections of EG&CAD will be introduced to the new material in the Fall and Spring semesters. This method has proven successful for the past several years.

The latest change to EG&CAD involves changing the manner in which the course final project is handled. In EG&CAD, a final assembly is given to the students to build and document. The assembly normally has 30 to 40 individual parts. Many of these parts are given to the students, the rest (normally 12 to 15 parts) are created by the students. All of the parts are then assembled and engineering drawings of the assemblies, sub-assemblies and parts are created. For the past several years, the final project has been given to the students in the 6th week of the course. In the new model, students were given the final project on the first day of class and did all class assignments from the final project. The focus of this paper is to compare how students performed with having a single project to create as opposed to working on text book examples for 8 weeks and then working on a final project.

Course Pedagogy and Implementation

EG&CAD is taught with a series of twelve one hour lectures over a fourteen week semester[2][4][5]. The first six weeks are spent learning how to create solid models of parts, one week is spent on assemblies of parts and the remaining five weeks are spent on creating engineering drawings. Students also create hand sketches of parts creating both isometric and orthographic projections. An additional textbook[7] is used to supplement the hand-sketching portion of the course. The last two weeks of the semester are dedicated to work on the final project. Each of the twelve lectures has an associated laboratory session where students work problems based on the lecture material. The laboratory sessions are two hours long. As EG&CAD is a one credit course, no additional work is assigned outside the laboratory; the goal of the lecture and laboratory is to contain the course to three hours each week.

In previous semesters, students created parts, assemblies and drawings that were selected to reinforce the lecture material. The course text book contains assignments specifically designed for each lecture. Each problem, whether it is a part, assembly or engineering drawing has 5 grading criteria that are used to evaluate the student's work.[1] These criteria were added to help students focus on the key points of the assignment and to ensure uniform grading across the multiple sections. An example of a text book part used to demonstrate a sweep (cross section following a guide curve) is shown in Figure 1. These examples were used for the majority of the laboratory sessions. Of the 22 problems assigned during laboratory sessions, 16-18 were from the text book. The remaining problems would be assigned from the final project. Like the assignments shown in Figure 1, the laboratory assignments based on the final project had 5 grading criteria.

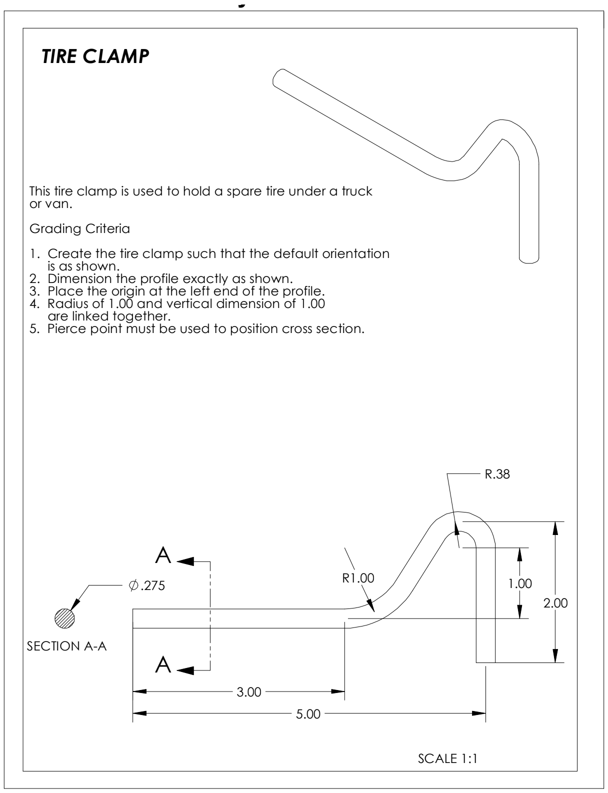

Figure 1: Sweep Example Course Notes[7]

Assignments based on a Single Assembly

In the new model, all laboratory problems come from the final assembly. Thus, students work on their final project throughout the semester. This has two major impacts on the course. First, it provides a single goal for the entire course by spreading the final out over fourteen weeks. Secondly, problems from the final project must be selected and often modified to allow students to complete them. This will be explained in more detail below.

For the Fall 2004 semester, a toaster was used for the final project. This is shown in Figure 2. The toaster was selected to tie in to a new course in the freshman year known as Engineering Discovery[1]. In Engineering Discovery, students examine common household products and discover how the math and physics they are learning can be applied to understand how these products work. The toaster was used to pilot the Engineering Discovery course as it has some interesting areas of study (radiation heat transfer, timing circuits, sheet metal manufacturing) and the toaster provides a challenging assembly to create and document in EG&CAD. The toaster final was so appealing, it was decided to let all students in EG&CAD create the toaster, not just the 30 students in the Engineering Discovery pilot program (for the Fall 2004 semester).

To aid in helping students understand the toaster in EG&CAD, the toasters were kept in the class room and students were encouraged to examine the parts they were creating. In addition, web pages containing the toaster assembly and all sub-assemblies were posted on the EG&CAD homepage (www.rpi.edu/locker/85/000685/public_html). These files were created from SolidWorks using eDrawings, a package that allows user to manipulate the SolidWorks data without SolidWorks. Thus students had both real and virtual toasters to examine as they did their work throughout the semester.

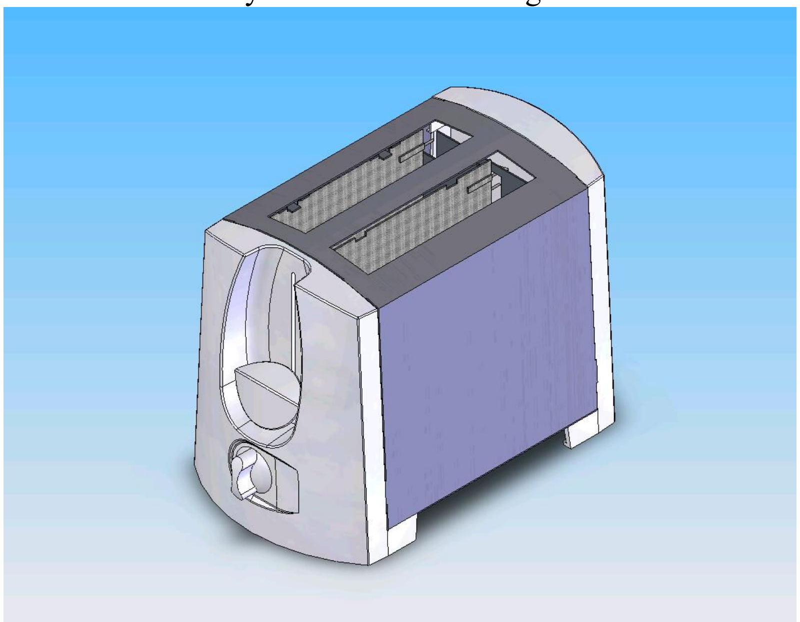

Figure 2: Toaster used for Final Project in Fall 2004

The grading criteria for the toaster assignments was the same as problems assigned in previous years (Figure 1). Students had to satisfy 5 criteria for every problem. An example of the sweep problem is shown in Figures 3 and 4.

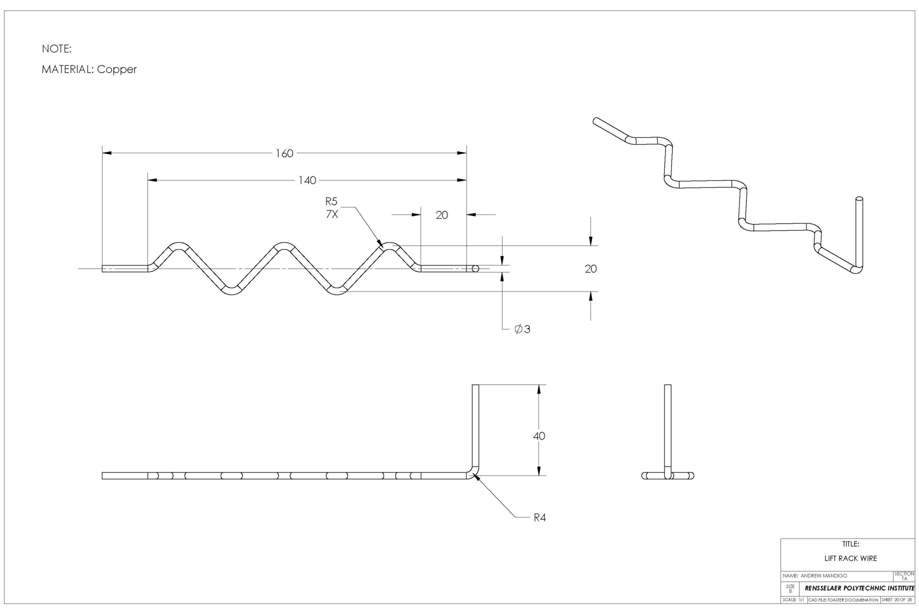

Figure 3: Dimensions for a Swept Solid Example

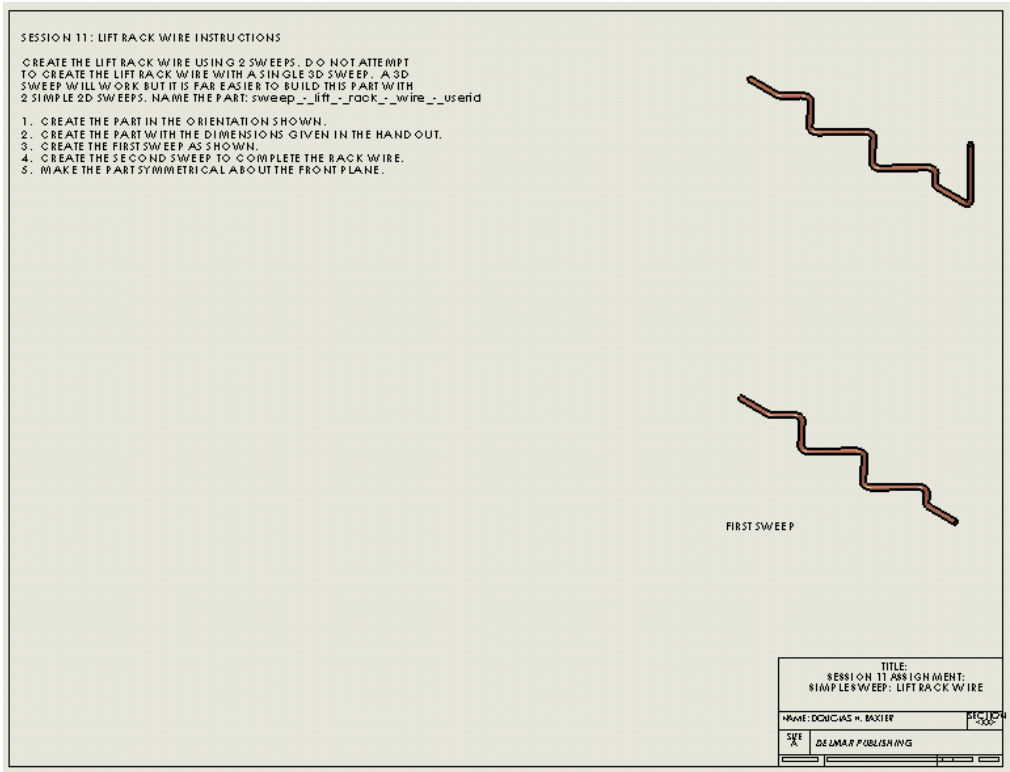

Figure 4: Grading Criteria for Swept Solid Example

In the lift rack wire shown in Figure 3, students create a simple 2 feature sweep of the lifting wire that holds the toast while the bread is cooking in the toaster. In this example, the students build the part in its completed form using the dimensions from Figure 3 and the criteria from Figure 4. The use of two drawing hand-outs (criteria sheets for the weekly assignments and dimensions handout) were done to allow the project to be used for multiple semesters with different grading criteria.

Some assignments required that the parts be modified or only partial constructed for the weekly assignment. For example, consider the lift rack front plate extension shown in Figure 5 and 6 in both its complete state (Figure 6) and as an assignment where the bend needed to secure the extender is not created (Figure 5). This problem is from the second week of the course where students are learning to create single feature solids of extrusion and revolution. As the lift plate extender requires two features, only the base feature was assigned. Students were told to complete the part after they learned how to create multiple feature parts staring in the fourth week.

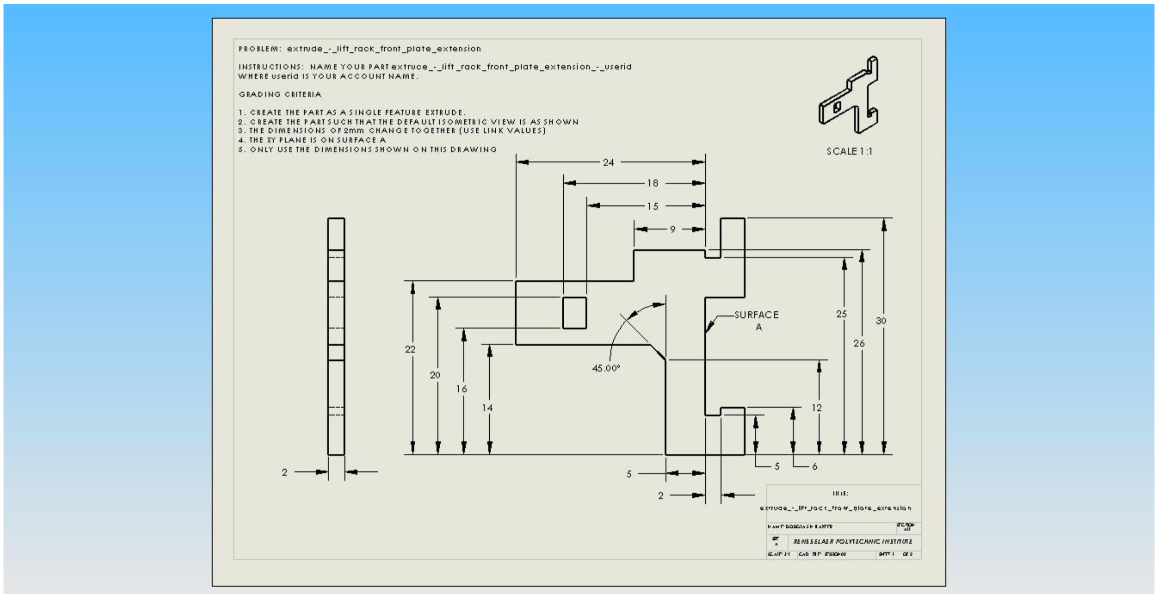

Figure 5: Partial build of the Lift Rack Front Extension Plate

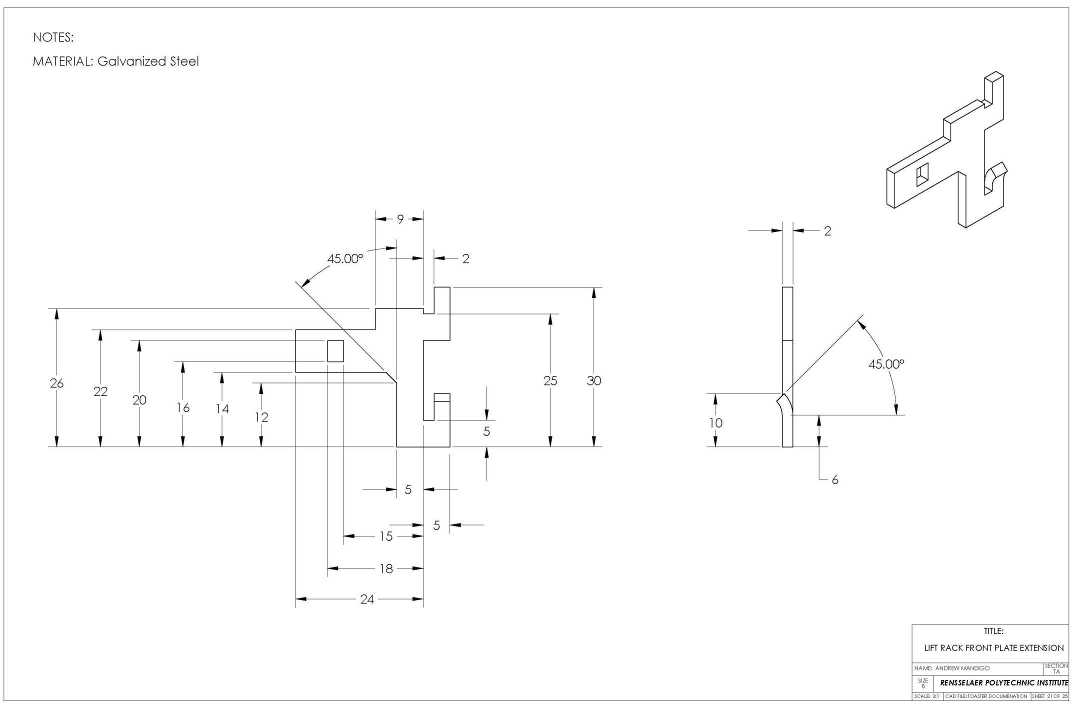

Figure 6: Complete Lift Rack Front Extension Plate

Since the toaster was the driving vehicle, there were also instances where only a couple of features were built for a particular part. Consider the case ends in Figure 5. The case ends were considered too complicated to be built by the students. However, the case ends provide an excellent example of building a feature using a sweep with guide curves to control the cross section control points. The solution was to have students build a single feature of the case ends demonstrating the sweep with a guide curve as shown in Figure 7.

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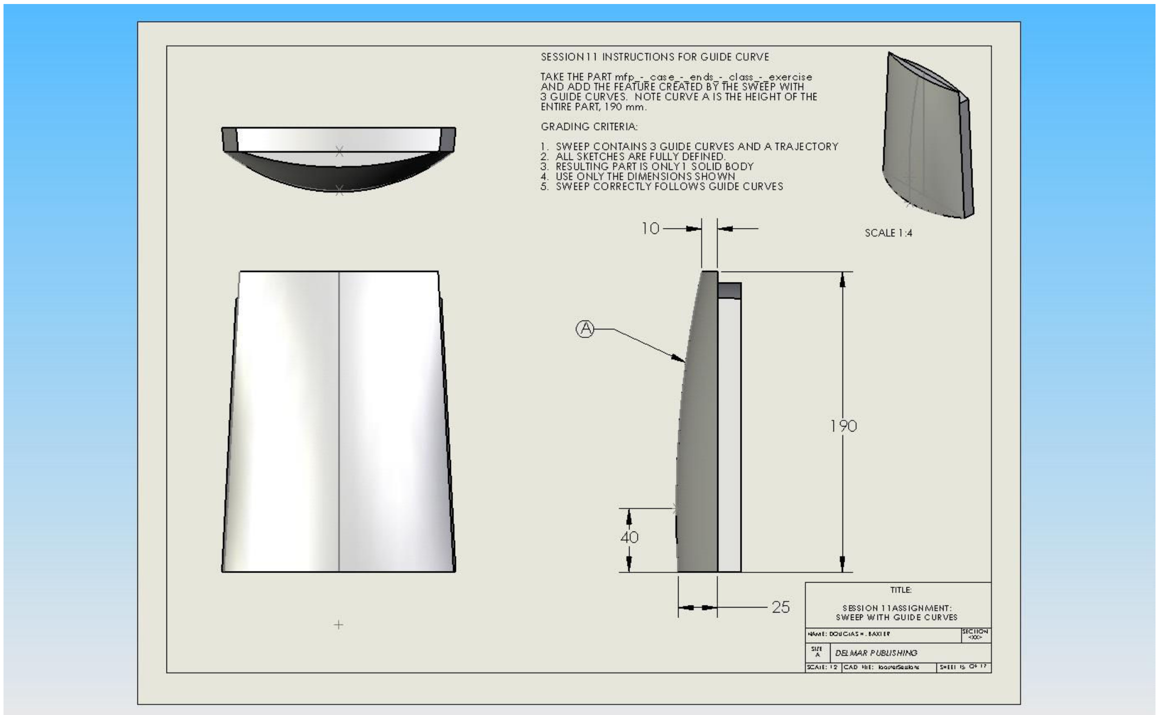

Figure 7: Sweep Example of Toaster Case End

The use of a single assembly as a course project is not new to the CAD community[9]. Numerous papers have been written on all the different pedagogies used to teach introductory CAD courses. The opportunity to compare the single assembly where assignments are coaxed from the assembly and the use of non-related assignments that focus on the lecture topics was too great to be ignored. The authors felt that a comparison between the two methods, both in their ability to provide information to the students, and the students overall reaction to the material presentation, were worthy subjects of study.

Evaluation

To help evaluate the effectiveness of the new course format, several techniques are used. To examine the effectiveness of the lectures, laboratory quizzes are given in weeks 3, 6, 9, and 12. These quizzes are worth 5 points and consist of a small solid model or drawing from the toaster that must be created by the student as a timed exercise during their laboratory session. The problems on the quizzes are similar to in class exercises. The major difference is students do not receive assistance from the teaching assistants while taking the quiz. Points are awarded using the same kinds of grading criteria used in the weekly assignments. Every effort was made to make the quiz problems look like a regular assignment.

In addition to the four quizzes, a 50 question quiz[10] (2 points per question) developed by Dr. Sheryl Sorby is used to determine overall course effectiveness. The test works with 2 and 3 dimensional visualization, measurement and technical drawing skills. In 1998, this test was introduced in EG&CAD as a paper test. In the Spring 1999 semester, the test was moved to WebCT.

This quiz is administered through WebCT and is given at the beginning and end of the course. Final averages are examined between semesters and between the beginning and end of each semester. Rensselaer students typically average between 25-35 points when they first take the quiz and average 70-75 at the end of the semester. While the final scores appear low, they are acceptable as the quiz examines topics not directly covered in class (specifically, using engineering scales and reading architecture drawings).

Traditional evaluation using opinion surveys continue to be used. Additional questions were included in the class survey. These questions dealt with the students' reaction to the use of a single project, their opinion as to the distribution of the workload in the course and their overall impressions of course.

Results of the Study

Comparison of the diagnostic test results from Dr. Sorby's exam showed that there was no significant change from previous semesters. The average exam grade at the end of the semester was 75, statistically the same as the last 5 years. As before, the students' ability to read engineering prints and visualize rotations increased over the course of the semester. Clearly, the new format does not improve or degrade the students' skills in visualization.

Results of the opinion survey were more dramatic. The mantra of "too much work for a 1 credit course" while still present, was far less prevalent in the Fall 2004 opinion surveys. While students still rate the workload as high, the write in comments were far more positive than in previous semesters. Students noted that they liked the single goal of always working on the final over the course of the semester. Many students also noted that having the toaster in the class room helped them visualize how they would complete their assignments. About 20% of the students mentioned that they felt that their curiosity in how things are put together increased because of this course; a comment rarely heard in past surveys.

Another measure of the increased satisfaction is in the raw scores for the survey questions. Each question is rated on a 5 point scale (from very dissatisfied, 1, to neutral, 3, to very satisfied 5). The class average for the overall satisfaction question rose from an average of 3.1 (for the last 4 semesters prior to the Fall 2004 semester) to 3.9. Similarly, questions pertaining to the key course contents rose between half and three quarters of a point. The authors are hesitant to claim an improvement with only one data point, but are (at least) encouraged at the rise in score. The authors plan to fully analyze the results from the Spring 2005 pilot and add these results to the Fall 2004 pilot to provide a better foundation for the statistics.

An interesting note is that the undergraduate teaching assistants were the most vocal in their objection to the course format. They felt the new format made the course too easy.

Some justification to their concern may be noted. The course average grade point average rose from 3.1 to 3.3 for this semester. A careful examination of the course quizzes showed that a large portion of this increase occurred in the quizzes (the average quiz grade went from 3.5 to 4.5). This may have something to do with using toaster parts as the quiz parts. It as noted that the quiz average rose during the week the quizzes were given; that is, the Monday scores were a almost a point lower on average than the Thursday and Friday scores. The authors strongly suspect that the freshman grapevine was heavily utilized to produce this result. To test the validity of this theory, the Spring 2005 semester will have quizzes that do not come from the final project. In addition, multiple instances of the quiz will again be employed to ensure that the Monday students do not have the same quiz as the Friday students. For the first 2 quizzes given during the Spring 2005 semester, the average score has dropped back to 3.5.

Future Work

The format of a single assembly is again being used in the Spring 2005 semester. A blender is being used as the assembly (see Figures 8 and 9).

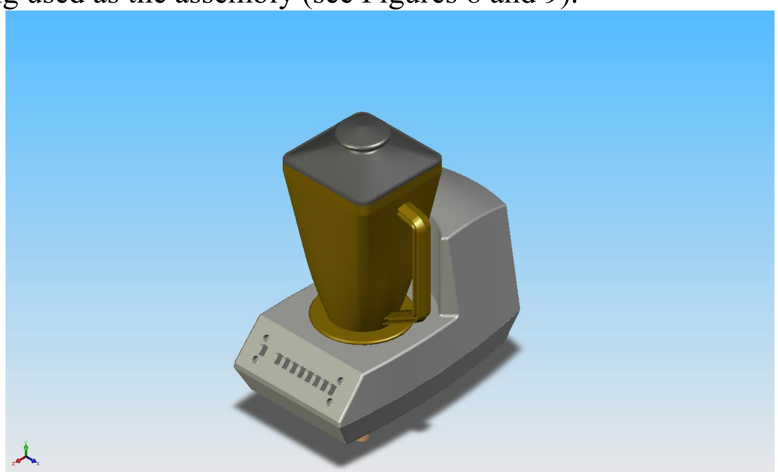

Figure 8: Blender Assignment for Spring 2005 Semester

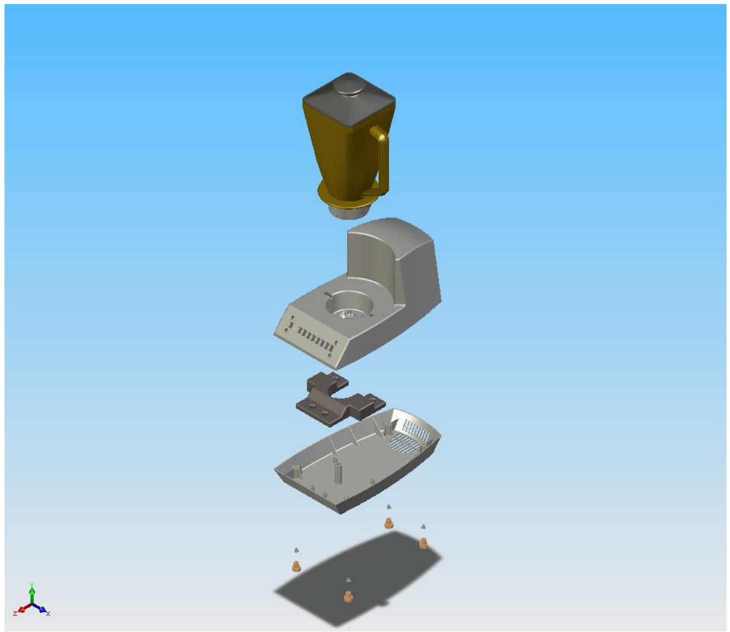

Figure 9: Exploded View of Blender Assignment for Spring 2005 Semester

It was decided to continue the course policy of introducing a new project each semester to avoid the temptation to borrow from previous semesters. In addition, if the data from the Spring 2005 semester matches the results from the Fall 2004 semester, then the confidence that the improvement is based on the course format and not the particular project is increased. Quizzes will no longer be drawn from the final project but instead, from other sources. It is hoped that this will better evaluate the students ability to do the work.

The new model of using a single assembly for the entire semester is proving successful. While diagnostic test scores have not increased, it is clear from the student reaction that they favor the new model and thus are happier at the end of the semester and more willing to apply their cad abilities in future courses.

SolidWorks is registered trademark of SolidWorks Corporation, Concord, MA.
WebCT is a registered trademark of WebCT.com, Vancouver, BC.

Bibliography

1. Baxter, Douglas, "Integrating CAD with a Technical Communications Program", *Proceedings, American Society of Engineering Education: Engineering Graphics Division Mid-Year Meeting,* Williamsburg, Virginia, November 2004.
2. Baxter, Douglas, and Lister, Brad, and Laplante, Bruce, "A New Model for a Self-Taught Solid Modeling Course", *Proceedings, American Society of Engineering Education: Engineering Graphics Division Mid Year Meeting,* San Antonio, Texas, January 2001.
3. Baxter, Douglas, "Expanding the Use of Solid Modeling Throughout the Engineering Curriculum", *Proceedings, American Society of Engineering Education: Annual Meeting*, St. Louis, Missouri, June, 2000.
4. Baxter, Douglas, and Bunk, Donald, *Engineering Graphics and Computer Aided Desig*n, Primus Custom Publishing, McGraw-Hill, New York, New York, 1999.
5. Baxter, Douglas, "Comparing Passive and Active Lectures for a Freshman Computer Aided Design Course," *Proceedings, American Society of Engineering Education: Engineering Design Graphics Divisio*n, Columbus, Ohio, January, 1999.
6. Baxter, Douglas, "Engineering Graphics and Computer Aided Design: A Foundation to Engineering Design and Analysis", *Proceedings, American Society of Engineering Education: Annual Meeting,* Seattle, Washington, June, 1998.
7. Bertoline, Gary, Wiebe, Eric, Miller, Craig, and Mohler, James, *Technical Graphics Communication, 2nd Editio*n, WCB McGraw Hill, Boston, Massachusetts, 1997.
8. Bunk, Donald and Baxter, Douglas "An Online Course In Solid Modeling", *Proceedings, American Society of Engineering Education: Regional Meetin*g, Union College, Schenectady, New York, September, 1995.
9. Duff, Jon, "Computer Modeling from Models", *Proceedings, American Society of Engineering Education: Engineering Design Graphics Division,* San Antonio, Texas, January 2001.
10. Sorby, Sheryl, Young, Michael "Assessment of a Visualization-Based Placement Exam for a Freshman Graphics Course", *Proceedings, American Society of Engineering Education: Annual Meeting,* Seattle, Washington, June, 1998.

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Andrew Mandigo is a mechanical engineering senior at Rensselaer Polytechnic Institute. Andrew learned to use solid modeling programs in high school to aid his father. While at RPI, Andrew has been instrumental in helping develop final projects for Engineering Graphics and Computer Aided Design as well as assistance in creating text and figures for the course text book. Andrew is presently helping expand the freshman course in manufacturing by adding modules on CNC and rapid prototyping.