Engineering Graphics in a Project Based Curriculum

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ABSTRACT- *A comparison was made between students in project based curriculum and those in non-project based curriculum to study the effect of project based curriculum on engineering graphics performance. Specific areas compared included common exam questions and a college wide freshmen graphics competition (the T.R. Spence Freshmen Engineering Competition). With an ά of 0.08, project focused students outperformed non-project focused students on common exam questions. In the graphics competition, project based students out sketched non-project based students (ά of 0.09) whereas there was no statistical difference between the two groups on the competition exam.*

I. INTRODUCTION

The Dwight Look College of Engineering at Texas A&M University enrolls close to 8,000 undergraduate students and awards over 1,300 Bachelor Degrees annually (Howze et al. 2003). The college is first in national enrollment but sixth in awarding degrees (Howze et al. 2003). Therefore, retention of freshmen engineering students at Texas A&M University is a primary concern, with 30% failing to enroll for sophomore level courses (Howze et al. 2003). This problem is enigmatic given that the college is very selective in its admittance criteria (average SAT score is 1220 and over 70% of incoming freshmen are in the top 10% of their graduating high school class) (Howze et al. 2003). Not all students who fail to continue their engineering studies cite problems with engineering classes as their motivation for a change of major. Oftentimes, students report that difficulties with math and physics are the impetus for their withdrawal from the College of Engineering. In order to alleviate this problem, the Colleges of Science and Engineering have collaborated on a project based curriculum pilot study curriculum (STEPS: Retention Through Applied Physics, Engineering, and Mathematics) to be used in several freshmen level introductory classes. Faculty members from the various disciplines, including engineering graphics, met to plan how to best integrate the subject material to assist in student comprehension. All fundamental principles directly correspond to ongoing class projects, with much of that information introduced in the students' calculus or physics classes, with all engineering graphics instruction occurring in the STEPS classes. Graphics assignments were given not only as homework, but each project had significant graphics requirements. The students were placed in teams of up to four members and the teams were also comprised of the same members for their calculus and physics classes. This cross-discipline approach is designed to instill in the students the idea that knowledge is not compartmentalized, but has applications in many different fields. An additional goal was to implant in the students an understanding that there are specific steps in applying the engineering process as opposed to trial and error approaches relied on in past projects. This program was instituted with two sections (approximately 200 mechanical, aerospace, and civil engineering students) for the 2004-2005 school

year and increased to five sections for the 2005-2006 school year.

II. GRAPHICS INSTRUCTION

Four hours per week of classroom instruction were divided between approximately 60% on engineering analysis and 40% on engineering graphics. (Froyd et. al 2005) No assumption of prior graphics knowledge was made for the freshmen students. Material presented covered general, introductory engineering graphics topics, including sketching and lettering, scaling, orthographic projection, dimensioning, pictorials, tolerancing, and parametric modeling. The software packages chosen to meet these goals were AutoCAD and SolidWorks. Topics were covered in a lecture environment, with individual, pair, and team homework assigned to reinforce each topic. Also, each project required the implementation of the graphics topic recently covered. As an example, sketching was covered during a truss analysis project, with the corresponding report requiring dimensioned, sketched, orthographic views of their truss.

Projects completed during the past academic year include a truss analysis project, a wheel chair lift to introduce gear trains and ratios, a construction estimation project to introduce students to engineering project management and cost estimation, a heat loss project, a shaker table used to examine a body's natural frequency, and a robot that navigated an elevated path using light sensors to traverse a black line course.

Six common exams were given during the course of the year. These exams were comprised of multiple choice and true/false questions as well as problems testing the students' ability to draw. Many of the questions posed were common to both the STEPS and the non-STEPS versions of the exams. On these common exam questions, STEPS students out performed Non-STEPS students by just over 2.5%.(α of 0.08).

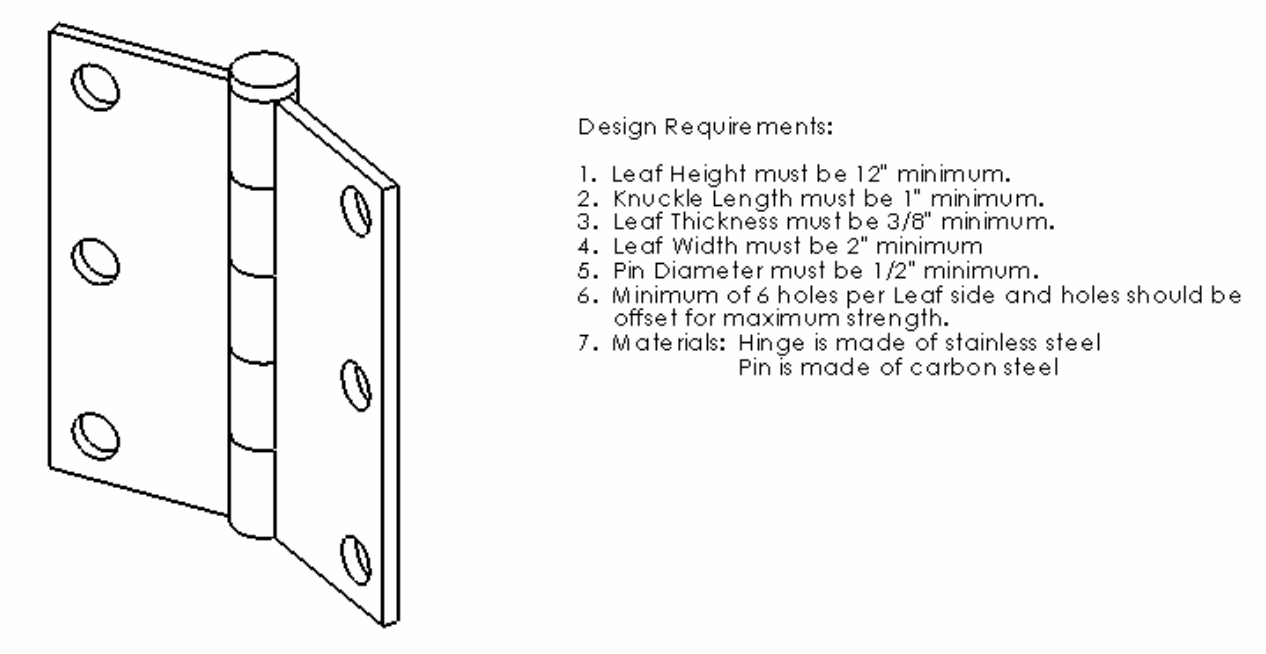

Figure 1 – T. R. Spence design competition 2004-05 academic year

III. T. R. SPENCE COMPETITION

The T. R. Spence Freshmen Engineering Graphics Competition takes place at the end of each academic year and pits the best freshmen graphics students against each other. The awards are not insubstantial, with an engraved watch, gift certificates, and software going to the top five finishers. The competition tests the students' ability in areas of sketching, general engineering graphics knowledge, and a hands-on parametric modeling design exercise. Approximately fifty students competed during the Spring of 2005: STEPS and Non-STEPS students. In the morning, a general multiple choice exam is given that covers most of the basic concepts of which the students have been instructed. Students use university identification numbers instead of their names to insure unbiased grading. On this exam, there was no statistical difference between STEPS and Non-STEPS students. This preliminary exam is used to select the finalists who compete in the afternoon session.

In the afternoon, the students are presented with a design problem which tests their ability to sketch and use a parametric modeler to create a set of working drawings detailing their design. The Spring 2005 design problem is shown in Figure 1. Students were given 3 hours to complete a set of design sketches and complete as much as possible of the design using a parametric modeler (either SolidWorks or Inventor). Some students opted to spend most of their time using the parametric modeler and some spent more time with the pencil and paper. The resulting submissions are examined by all graphics faculty and scored. Results from this session showed that STEPS students had superior sketching work than the Non-STEPS students by 11 points (α of 0.09), while there was no statistically significant difference between the two groups on the use of the parametric modeling software.

IV. CONCLUSIONS

While the evidence is scant to support the hypothesis that the project based curriculum improved the student's scores on standard measures, it can certainly support that no damage was done to their ability to comprehend and communicate graphically. Therefore, it is safe to say that using a project based curriculum, from the point of view of Engineering Graphics, is a perfectly acceptable method for teaching students the fundamentals. If there are other benefits from this approach, as have been reported by Froyd, Finelli and others, then these alternatives need to be pursued.

All completed projects were designed to reinforce in the students' mind the interdisciplinary nature of real world problem solving. Too many students categorize specific knowledge as "calculus information" or "physics information", without realizing the overlap and synthesis of all scientific endeavors. If students can be shown that fundamental principles and graphics concepts, regardless of the class in which it is first introduced, are applicable in many different areas, perhaps student dissatisfaction with basic, fundamental courses will subside and attrition will be reduced. Lastly, the emphasis of the engineering process was a constant theme in all of the projects. Both the faculty assigned to teach the engineering analysis and those assigned to instruct engineering graphics stressed the importance of the graphical component of the projects. Since the engineering graphic faculty were common to both STEPS and non-STEPS classes, one possible variable which could be used to explain the differences was the support given the graphics material by the engineering analysis instructors. Another possible difference could be the repeated exposure to sketching for each and every project assigned, even though the projects seemed to be "analysis" projects. By requiring some graphical submissions for all projects, students

were shown that engineering graphics are relevant to the engineering profession.

This project based curriculum was only offered to two classes during the past academic year, but is being ramped up to five classes for the upcoming year.

V. REFERENCES

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