Integrating Computer Aided Design with Technical Communications in a Freshman Engineering Program

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ABSTRACT – Engineering students have complained that they can not understand the difference between a general science degree and engineering until their third year of college. In an attempt to educate and excite students about engineering, an Engineering Discovery course was developed at Rensselaer. Engineering Graphics was seen as an integral part of this course within its context as being a major tool in Technical Communications. This paper presents the lessons learned in teaching the introductory graphics course at Rensselaer within the contexts of Engineering Discovery and Technical Communications.

I. Introduction
When introducing solid modeling to students, the introductory course is often broken into three main components: part creation, assembly creation, and engineering drawing (documentation creation). With each of these three components, the goal is to get the student thinking between two and three dimensions.

While providing the student with fundamental background in visualization and solid modeling, it has been found that students often have difficulty taking this knowledge in their other courses. Many students will spend time to create superb engineering drawings of parts and assemblies, only to place them in the appendix of a report, ignoring them and then spend several paragraphs describing the engineering drawing! Furthermore, students pass up opportunities to use the documentation (and the solid models) to aid them in the design and manufacturing of the assembly; rather, they tend to treat engineering drawings as a final product of the design process instead of a working part of the design process.

The lack of connections between Engineering Graphics and the rest of the engineering courses led to the idea of combining engineering graphics with technical communications. An additional effort was already underway at Rensselaer to provide students an engineering experience at the freshman level. The natural conclusion was to combine the efforts and combine the engineering graphics and technical communications within the new engineering course.

II. Engineering Discovery
The new engineering course is called Engineering Discovery. The goal of Engineering Discovery is to have students examine common products and see how the physics, mathematics, and chemistry that they are learning in their science courses can be used to understand the product. Unlike many “reverse engineering” courses, Engineering Discovery does not attempt to have students fully model the product or make any improvements. Rather, the students study
certain aspects of the toaster and from them they can see that the science they are learning can be used to understand the behavior of the device.

Engineering graphics was quickly recognized as an essential element to Engineering Discovery. As students study the parts in the assembly, they can also be learning to model them on the computer and using the computer model to generate data and compare this data to data collected in the laboratory. In addition, the engineering documentation (solid parts, solid assemblies, and drawings) can also be imbedded into the students’ memos and reports. Thus students use the engineering graphics to communicate and discover all while still gaining fundamental visualization skills.

In addition to Technical Communications, additional support modules were included in the Engineering Discovery experience. The additional modules are computing and measurements. As these other modules already exist as 1 credit freshman courses, they (along with Technical Communications) were evolved from their predecessor courses into support courses for Engineering Discovery allowing the Engineering Discovery to be given as a technical elective in its pilot mode with the support courses being treated as the existing 1 credit courses. In this way, the students in the pilot program do not fall behind. The hope is that students in the pilot will have an advantage when they enter their first design course in the sophomore year as they already are use to looking at an assembly at a system level.

III. Technical Communications Pilot Program

The initial pilot of Technical Communications was run in the Spring 2004 semester with 28 students. An additional section was run in the Summer 2004 session. As the Engineering Discovery course was introduced in the Fall 2004 semester, the Technical Communications course was not fully implemented. Rather, the concept of examining one assembly for the semester was examined. The assembly used in the two pilot courses (as well as the full Engineering Discovery pilot in the Fall 2004 semester is an inexpensive 2 slot toaster. The solid model of the toaster is shown in Figure 1.

![Figure 1: CAD Model of a 2 Slot Toaster](http://www.rpi.edu/~baxterd/EGCAD)

In all 3 pilot sections, students have been asked to create pieces of the toaster each week. Students do not build every part as this would be excessive for 1 credit of work. Several of the parts are stored as STEP files and given to the students in a zip file they download from the course web page. A STEP file is used instead of giving them a full SolidWorks file as it introduces the students of working with non-native files in a solid modeler. It also was a way of working around having 2 versions of SolidWorks active on campus in the Summer

1 Readers are encouraged to visit the web site at http://www.rpi.edu/~baxterd/EGCAD to see the full syllabus and documentation of the toaster.
2004 section. For weeks 2 thru 12 in the semester, students build one or two parts of the toaster along with the accompanying engineering drawings. They also build the electronic sub-assembly in class. This sub-assembly is shown in Figure 2.

Figure 2: Circuit Sub-Assembly
This sub-assembly was selected as its workings are studied in Engineering Discovery. Students take measurements on the timing circuit as well as studying the triggering mechanism and the resulting heating from the heating elements. By the end of the 14 weeks, students build 20 parts and then build all the sub-assemblies (as shown in Figure 3). Finally, students create a multi-sheet engineering drawing of the toaster assembly, the sub-assemblies, and the parts they created during the semester.

Scattered throughout the 14 weeks, students are also introduced to a wider spectrum of technical communications. In the first week, students are taught how to keep an engineering journal which they use in Engineering Discovery and all the support modules. Students are asked to write weekly memos for Engineering Discovery and are shown how to include their CAD, measurements and computing work within their writing. Students are shown how to create oral presentations to back up their memos and reports. Using imbedded objects, students learn how to create dynamic CAD models within their reports and oral presentations. Rapid prototyping is introduced in week 2 and then students have an opportunity to build their own toaster on a Z-Corporation rapid prototype 3D printer. Finally in weeks 13 and 14, students take the contacts from the circuit assembly and do a bending analysis in COSMOS to compare to the analysis they did in weeks 3 and 4 in measurements. In this way, students can see how the many tools introduced to them in the freshman year can be used to help them understand their work in future engineering courses. In addition, students learn that there is often more than one way to obtain data with inherit strengths and weaknesses in each of the methods.

IV. Initial Observations
With 2 semesters of running Technical Communications as a stand-alone course, and almost 1 semester of running Technical Communications as a support course for Engineering Discovery, several observations can be made. The key observation noted in all discussion groups and student surveys is that students find working on one assembly for the
The first half of the course is preferred over working on random parts for the first half of the course and concentrating on the final assembly in the latter half of the course (the model for Engineering Graphics in previous years). The old system had students building more parts for the final project outside of class and thus, building more parts in the semester (about 30 as opposed to the 20 in the pilot programs).[2] Not surprisingly, students find the single focus of one project appealing. When creating the Technical Communications course, there was concern that reducing the number of parts and using only one assembly may decrease the students overall level of expertise by the end of the course. With the old model, parts were chosen based on their fit with the lecture material. In the new model, parts from the toaster had to be made to fit the course objectives. In most instances, this was not a serious problem but in several cases, students would only partially build a part in the earlier lecture as they didn’t have the necessary lectures to fully build the part. Thus students in the new model often work on a part over several weeks. This has been found to be advantageous as it appears to provide the students with a firmer grasp of the modeling strategy needed in creating complicated parts and assemblies.

Students take a diagnostic exam at the beginning and end of the semester. The test was developed by Dr. Sheryl Sorby at Michigan Technological University. [3] Test scores for the first two pilots track with test scores from the past five years. Students average a 24 at the beginning of the semester and a 76 at the end of the semester. The third pilot final diagnostic exams will not be available until after the publication of this paper but the results will be included in the 2005 ASEE National Meeting Proceedings.

Another observation from the students is the enthusiastic response to working with physical models. Students work with the real toasters in Engineering Discovery and the support modules. Toasters are available in the classroom for students to examine. In addition, virtual models of the toaster are online at the course webpage (see footnote 1). Students also enjoy making rapid prototypes of the toaster. The toaster has been scaled down to ¼ size and all the internal components were removed. Students can emboss their name on the side in raised letters and thus personalize their work. An example of the rapid prototype toaster is shown in Figure 4.

![Figure 4: Rapid Prototype Toasters](image)

A final observation from the 3 sections of Technical Communications is the enthusiasm of the students. For the past 5 years, about 10% of the students finish their CAD assignments early, another 65% finish their assignments on time and the remainder fall behind in their work. For the three sections of Technical Communications, the on time or early delivery rate of work is closer to 85%. More data points are needed to verify this result. In all three sections, the author
has taught the sections (instead of letting graduate students run the section). The author also has selected outstanding undergraduate teaching assistants to aid in the classroom. The higher percentages of on time work may be due, in part, to the extra attention given to the students. As these are pilot programs, the students meet several times with institute statisticians, administration and faculty. They are fed vast quantities of pizza in return for their feedback on these sections. They are getting enormous attention from the institute and that, in turn, puts pressure on them to perform.

V. Future Work

Two sections of Engineering Discovery (and hence two sections of Technical Communications) are planned for the Spring 2005 semester. To address the concerns outlined in the previous paragraph, the author has requested that one of the two sections of Technical Communications be led by a graduate student. The administration’s decision on this request has not been decided at this time.

To further explore the higher rate of on time delivery of data, the author used the toaster model in all sections of the current engineering graphics course in the Fall 2004 semester. Thus, there are 16 sections (with approximately 28 students/section) where the model of using one assembly all semester long is being evaluated. Results from this examination will be presented in the 2005 ASEE Annual Conference.

Additional work is continuing with automating the Technical Communications course so that grading is done automatically. [3] The present goal is to automate the grading in the support courses (computing, measurements, technical communications) wherever possible to allow for the program to scale from 1 section of 30 students to 700 students/year.

At present, it is too early to state that combining engineering graphics with other forms of technical communication is an improvement over teaching engineering graphics as a standalone course. The initial data is promising, but more data is needed to confirm the preliminary courses. What is clear is that students enjoy the new format, and this is clearly expressed in their comments. Unlike past generations, today’s entering engineering students do not have a clear idea of what an engineer is and how engineers work. Tailoring the freshman year to address this issue appears to help students understand the engineering profession in general giving them a better appreciation of the mathematics and science courses. Even if scores are not improved with this teaching model, if students are comfortable with their decision to enter engineering and eager to study, the effort spent in developing the Engineering Discovery program will be time well spent.

VI. Citations
