AC 2008-666: USING A TWO-COURSE SEQUENCE IN TECHNICAL DRAWING IN THE ENGINEERING TECHNOLOGY CURRICULUM THAT ESTABLISHES A BASELINE OF KNOWLEDGE, PROMOTES INDEPENDENT WORK AND LIFE-LONG LEARNING, AND INTRODUCES STUDENTS TO RAPID PROTOTYPING

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Abstract

Our university uses a two-course sequence to teach students the elements of technical drawing in both 2-D and 3-D. Students start with instruction presented in a lecture-type format but by the end of the sequence they are successful at self-paced instruction. The first course is designed to introduce students to 2-D electronic CAD in a structured lecture format but uses a tutorial-type of text. This allows students some opportunities to work independently and get ahead of the course syllabus but retains the lecture format to make sure that all students complete the course with a baseline of technical drawings skills and knowledge. This course is followed by instruction in 3-D solid modeling. This second course involves minimal lecture time and is primarily a student-paced course with instructor assistance. The text for the course is also a tutorial and since students have been introduced to this type of instruction in their initial CAD experience, they are able to quickly move into this student-paced course. Although the concern is that students will procrastinate when made responsible for their own learning, one important key to keeping this method successful involves the use of rapid prototyping as part of the solid modeling course. Each student must complete a final project in the solid modeling environment that will then be created for them on a rapid prototype machine. Seeing and having their project in a physical form motivates the students to work ahead and be committed to their own education. It is one of the early stages in the department's program to instill self-reliance and life-long learning into the students skill set. This paper will discuss how this two-course sequence is organized with its emphasis on instilling independent learning into the student experience.

Introduction

Engineering Education faces a problem of retention of students in the first few years of college. Some literature suggests that we may be losing as much a 50 % of the students.[1,5] Some suggest that students from minority schools would greatly benefit and are more accustomed to a greater teacher interaction and individual support.[2,6] These alone are a clear indication that we need to reexamine the traditional lecture method of delivering course material and look at new ways to reach students and find new ways of teaching. Further evidence that a shift in education methods is needed can be attributed to the fact that once students enter the workforce they will be required to become productive with new tools for design in a very short time as technological advancements continue to change the manner in which they work. This skill needs to be developed while at college to apply once the student graduates, since industry also will require them to learn new design tools quickly to improve their competitiveness in the ever changing world we live in.[3,4] The question is, How can we try to accomplish meeting these challenges in the Engineering Technology curriculum?

The answer is that we need to engage the students, be more involved with each one, develop a practice in the student to learn new technologies quickly and then help them become more self-directed so that they will start their journey of lifelong learning. Vygotsky suggests that the method of "scaffolding" could be used to gradually support the student at first and then gradually have the student be responsible for his/her own learning.[7] The practical applications of the scaffolding method have the following traits. Emphasis is placed on the student's current difficulties and concerns in the course. The instructor is able to give immediate availability of assistance to the individual student with adequate amounts of explanation and guidance to match each learner's competence. Then ultimately, the instructor aids the student in becoming self-aware of their own learning process with decreasing amount of "scaffolding" to support the learning procress.[8,9] The two course sequence in graphic design was developed and modified to first address the issue of retention and second to address the issues of increased teacher mentoring in a course. This was implemented using a "scaffolding" method to initially support the student with the extra attention needed and then to help the student develop his learning skills to need less and less "scaffolding" to accomplish learning of new technology tools and processes.

Student Preparation

Students in our Technology and Engineering Technology programs are all required to take a two-course sequence in 2-D and 3-D Engineering Graphics. It is expected that students coming to the department would have had at least a year of drafting or CAD experience in high school. If a student lacks this experience then they are required to take an introduction to technical drawing course that covers the basics of technical drawing. Some statistics have been gathered over the past few years to determine how many students come into the department having met this expected level of technical drawing experience. It has been found that 67% of students lack sufficient background in technical drawing and require the pre-requisite course. It has also been found that only 28% of students enter the program with some AutoCAD experience. Another 2 to 3% have some experience with other CAD-like software. Previous technical drawing experience is a pre-requisite for starting the 2-course sequence but the type and depth of this experience varies widely. Even some students that have met the requirements to start the AutoCAD course decide to take the pre-requisite course as a refresher. A few other students meet the experience requirement from on the job training. A few take introductory classes at community colleges.

Course Sequence and Description

Once a student meets the prerequisite requirement they start off in a quarter-long course in 2-dimensional orthographic projections. AutoCAD is the software used for this course. A decision was made four years ago to replace the current text with one that was almost purely a tutorial-style of textbook. Historically, students in the program came from rural and technical backgrounds and therefore abilities to understand technical drawings was somewhat of a given. Hence, the initial text was primarily concerned with the instruction of using the AutoCAD software. However, the current student body is more diverse and much more likely to not have come with a technical background and therefore a text that also included information on technical drawing principles was adopted. This first course follows a mostly traditional lecture-

style format but uses the tutorial-style text. It should also be noted that most of the students in the AutoCAD course are freshmen or sophomores and this is likely their first course taken in the Engineering & Design department. Since this is generally the first exposure for most students to technology and engineering technology courses it is important that they start off well. That is one of the reasons that a traditional lecture format was retained in this course. This format allows the professor to keep a closer hold on student performance. It maintains set deadlines for homework assignments and prevents students that are still relatively new to the college environment from procrastinating and failing. The typical pattern for instruction in this class involves the instructor discussing the current principle of technical drawing to be learned by the students. Then he demonstrates how to use the software to create that type of drawing. Then an assignment is given for the students to follow the tutorial in the text that follows the same material just covered by the instructor. This reinforces what the instructor taught in class, and also allows them to take the instruction with them in the text. When they have questions about what they learned they use the tutorial-style textbook to obtain an answer and in doing so they start training themselves on how to work independently. Students may not realize it but they are learning how to use this type of text to teach themselves. During this course the instructor spends quite a bit of time with the students in a lab type structure to provide the one-on-one "scaffolding". As the course progresses the student is encouraged to find answers and skills using the tutorial type text. This allows some of the "scaffolding" to be removed.

When it is time for the follow-on 3-D CAD course, the students are well-prepared to use a tutorial text and be able to set their own pace. This is the approach used in the second course using Solid Works as the 3-D software. Certain principles are covered, especially towards the early part of the course, but then assignments are given, maximum due dates assigned and students have more freedom to complete them at their own pace. The instructor spends most of his time in active mentoring of students over any rough spots they encounter. This encourages independent learning while not throwing the student in over his or her head.

As a final incentive for students to take charge of their learning and stay on track in this self-paced course, each student must complete a final project. The students get to choose an item that they will create in Solid Works. Giving students the freedom to choose their project adds to the success of the self-paced nature of the class. This also allows the final removal of the "scaffolding". Additionally, once the student successfully completes their 3-D design, they then will have the object physically created in ABS plastic on a rapid prototype machine. The incentive that this offers has had students tackling some very ambitious projects. Often the student self-selects a far more complicated project then the instructor would think of assigning. Some past examples have included a complete constant-velocity joint for automotive use, bearings complete with inner and outer races, an automobile crankshaft, and many others.

Instilling Independent Learning

Through the use of the tutorial-style texts and progressively increasing the self-paced aspect of the course material as the student moves through the two course sequence, the student is gradually introduced to independent learning in a safe and mentoring environment. The supporting "scaffolding" is removed a little at a time. Using the reward of actually seeing and holding their design through the use of the rapid prototype machine encourages the student to

move through the second course as fast as is comfortable for him/her so that there is more time to spend on the final self selected project. The student has taken his/her first steps in independent learning. The ability to learn independently is one of the keys to the path of lifelong learning. Making sure the student is successful in their first try of independent learning in a technical area builds the confidence to have the courage and drive to try further independent learning and hopefully lifelong learning.

Student Comments and Experience

Students are surveyed in each course using two separate instruments. The first is a universal student assessment of the course, how it was taught, and the effectiveness of the instructor in teaching the course. The second assessment tool is keyed to learning objectives which are mapped to the ABET criteria. Both assessments allow for students to write any comments they wish to add. Using both of these tools the instructor gets not only how the students felt about the course in general but details on how well the students feel that they have met the learning objectives of the course. The student response to the courses has been very positive. They like the gradual freedom given as the student progresses through the two courses. They are able to learn to progress at a pace that is right for them. Students have commented that they feel that they get more one-on-one time with the instructors. We hope to gather data in the future that this added on-demand attention of the instructor has led to better retention. The students have been able to create designs that they drafted and then produced a physical model using an ABS plastic rapid prototype machine (see Figure 1) and then in later courses actually using the machine shop to build the item. Figures 2 through 5 show student models created. Students who choose to then make a final, functioning version of their object in the machine shop have experienced a full closed loop of the design process.

The two courses described here do not require high level math and therefore we are able to have students take these courses while they are navigating the math courses. This allows us to help the students stay motivated and to help keep their interest in the major while taking foundation courses in math and physics. Students have liked the fact that they can experience the two courses while taking the foundation courses. The authors feel that this has helped the students feel connected to the major/department and increased retention by keeping the students interest up.

Figure 1
Rapid Prototype Machine Used in 2nd Course

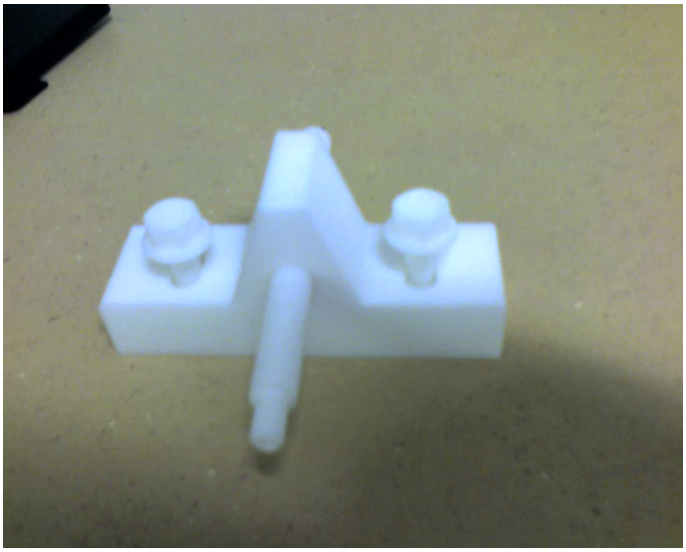

Figure 2
Prototype Model of
Assembly Done In First Week of Second Class

Figure 3
Prototype of Camera Design

Figure 4
Roller Bearing Model

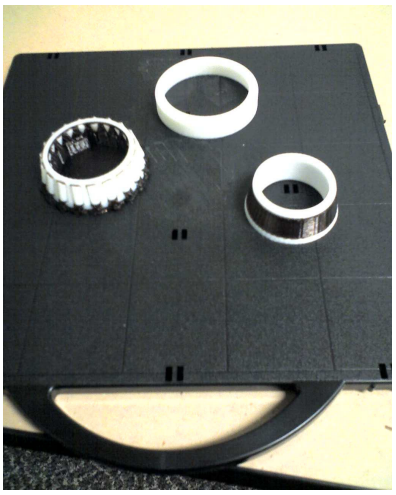

Figure 5
Taper Roller Bearing Design

Lessons Learned

At various times consideration has been given to making the introductory AutoCAD course more of a self-paced course to accommodate those students that already have previous AutoCAD or other CAD software experience. However, experience shows that this is not the best method to get the students started in their program of study. The introductory AutoCAD course is usually the first course students take in our department. Consequently, many of the students are still adapting to the college academic environment. In observing many quarters of teaching this course it is often the students with previous AutoCAD experience that falter a little mid-quarter. This type of student often assumes that the course will take almost no effort since they have some experience with the software, however their knowledge and skill level is quickly surpassed and they find themselves not allotting the proper time and effort to the course. A concern if this were a self-paced course is that these students would not make it to the end. Having a more traditional lecture course allows the instructor to get them better prepared for the workload and for how to use a tutorial text to their advantage. In the second course the instructor has had to space due dates throughout the course to make sure that procrastination does not set in to keep some of the students on track. The instructor in the second course has also needed to ensure that the students do not attempt a project that is too complicated or long to complete within the time frame of the course. The final project grading has developed to include both a grade for difficulty has well as execution. In this way a student is not penalized for choosing a more difficult project and ensures that a student does not select something as simple as an eight sided door stop for the final project.

Reflections on the Future

Currently students without a background in drafting are required to take a prerequisite course taught within the department. Engineering technology students as well as visual design majors are combined in this class. With anticipated growth in the department it appears that we will have additional faculty and thus the possibility of teaching a section of the prerequisite course for engineering technology students only. This opens the possibility of re-looking at the engineering graphics sequence and treating it more as a three course sequence than a two course one. It is felt that this would even further enhance the development of self-reliance that students currently develop during their engineering graphics experience.

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