Introduction to Engineering Technology: VSU's New Approach

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Abstract –The Engineering Technology Programs at Virginia State University are in the process of converting the 'Introduction to Engineering Technology' course to a modular format designed to accomplish the following specific objectives: improve program retention, satisfy more ABET requirements, and clearly distinguish the Engineering Technology from the Engineering program. To achieve these goals, the course overhaul included the addition of math remediation, formal teamwork exercises, and concept-based hands-on activities. The redesigned course was first introduced in the fall of 2003 and has undergone continuous improvement each subsequent semester. In this paper we will summarize our methodology, share our experiences, and include suggestions for future directions.

Keywords: teamwork, hands-on instruction, remediation, modules, retention

INTRODUCTION

Virginia State University (VSU) has two accredited engineering technology programs; one in Electronics Engineering Technology and the second in Mechanical Engineering Technology. Typically, the entering freshman class in engineering technology has about 20 to 30 students with 10 to 15 students graduating every year. One of the engineering technology courses that the freshman class is required to take is "Introduction to Engineering Technology". Historically, the 'Introduction to Engineering Technology' course would be taught from the textbook, [Eide, 1], covering topics that included the design process, engineering solution format, presentation of technical information, units and conversions, and selected topics in engineering technology (for example, mechanics and electrical theory). In the previous approach the entire course content was delivered using a chalkboard and instructor as the primary means of transmitting knowledge to the students. We wanted to change this approach because of the following reasons:

1. Retention: Many incoming freshman have deficiencies in mathematics. In the past, VSU has been able to support remedial classes for students that were weak in mathematics but unfortunately for the past few years remediation classes have not been offered. This has created a retention problem; students who are weak in mathematics tend to find engineering technology courses difficult and eventually opt out of the programs. Therefore, we included math remediation support in this course to better prepare the students for their engineering technology courses.

2. ABET requirements: In an effort to satisfy more ABET program outcomes [2], specifically (c – an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes), (d – an ability to apply creativity in the design of systems, components or processes appropriate to program

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objectives), (e – an ability to function effectively on teams), (f – an ability to identify, analyze and solve technical problems) and (g – an ability to communicate effectively), teamwork exercises, projects and hands-on laboratory experiments were added to the course.

3. Engineering & Engineering Technology distinction: There is often significant confusion about the difference between Engineering and Engineering Technology programs. Historically, the Introductory Engineering course and the Introductory Engineering Technology course have had very similar content and instructional strategies and therefore contributed to this confusion. In an effort to eliminate this confusion, we have included several hands-on experiments to demonstrate a defining characteristic of the engineering technology programs, i.e., technology programs are more hands-on than the engineering programs.

VSU'S APPROACH

To address the issues outlined above, we are making changes to our curriculum and the method of instruction. Since 'Introduction to Engineering Technology' is the first course for students in our program, we think it gives us the best opportunity to establish a productive learning culture that will enable the students to grasp engineering technology fundamentals in a more meaningful and enjoyable way. We started with this new approach in the fall semester of 2003. We have made some improvements since then and in this paper we share our experiences, findings and future directions for this course.

This is a two credit hour class with three contact hours. The class is held every Monday, Wednesday and Friday for fifty minutes. For ease of instructional delivery, to avoid confusion and to emphasize importance of basic math skills, we decided to modularize this course. In this approach, the course is broken into three modules or components:

Component 1: Introduction to Engineering Technology

Component 2: Important Engineering Principles

Component 3: Review of Basic Mathematics and Science

Component 1 is taught on Mondays, Component 2 is taught on Wednesdays and Component 3 is covered on Fridays. Figure 1 shows a detailed break down of the course for the fall of 2004. Subject matter covered in each component is presented later in this paper. First we discuss the diagnostic test.

Diagnostics Test

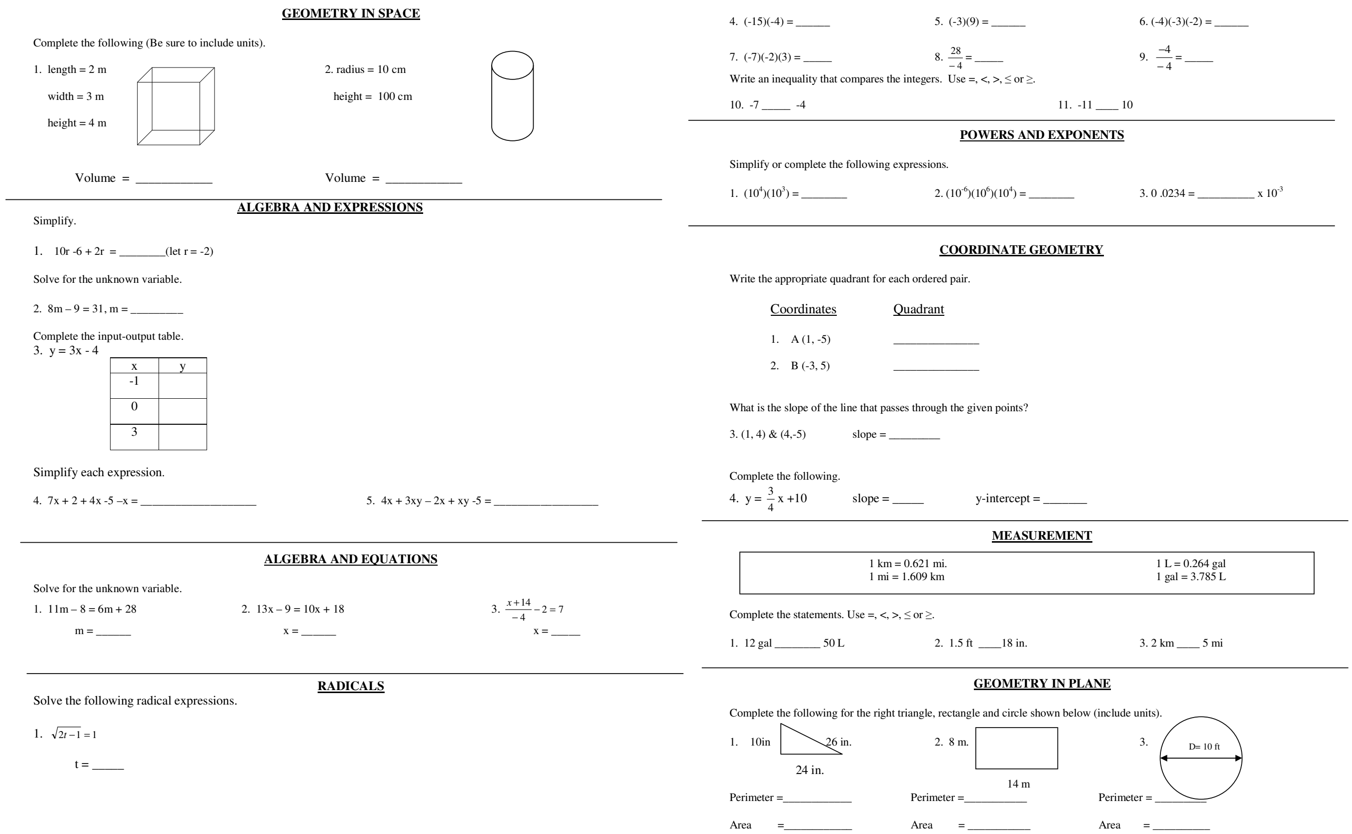
To uncover deficiencies in mathematics, a math diagnostic was administered during the first week of class for the fall 2003 semester. To reserve more time for instruction, we have modified the diagnostic to be completed in one class meeting instead of three classes. The first part of the diagnostic is a 40 minute basic math skills test that does not allow the students to use a calculator. The second part is a ten-minute calculator proficiency diagnostic. The topics covered in the basic math skills diagnostic test are: fractions, decimals, integers, ratios, power and exponents, coordinate geometry, plane geometry, space geometry, algebraic expressions, algebraic equations, and radicals. The range of topics for the diagnostic test were selected based on their importance in the engineering technology curriculum and their importance as fundamental math skills. Two pages from the diagnostic are presented in Figure 2. The average diagnostic test score for the fall of 2003 was 56%. The same test was administered at the end of the semester and showed an improvement of 4%. The goal is to find students' deficiencies at the beginning of the semester, try to rectify the problem during the semester by teaching them topics that where collectively the most difficult (in component 3), and test the efficacy of approach by testing them again at the end of the semester.

As mentioned earlier, for the fall of 2004, we have made changes to the diagnostic test (made it shorter). The average score for this diagnostic test was 64% for fall, 2004. We administered the same test at the end of the fall 2004 semester and saw an average improvement of more than 10% in the test scores. Our goal for each semester is

COURSE SCHEDULE FOR
ENGT100 – INTRODUCTION TO ENGINEERING TECHNOLOGY

WEEK	MONDAY COMPONENT 1 Introduction to Engineering Technology	WEDNESDAY COMPONENT 2 Important Engineering Technology Principles	FRIDAY COMPONENT 3 Basic Math Skills
1	Introduction to department, course & Blackboard	Introduction of Faculty, and department tour	Diagnostic test
2	Team Work Exercise#1 – El Nino	Engineering solutions – Chapter 3	Fractions
3	Labor day	Rep. of tech. info – Chapter 4	Decimals & Integers, Quiz#1 – Fractions
4	Intro to Engineering career – Chapter 1	Rep. of tech. info – Chapter 4	Ratios, Quiz#2 – Decimals and integers
5	Intro to Engineering career – Chapter 1 & student organizations	Test# 1 – Chapters 3 & 4	Power & Exponent, Quiz#3 - Ratios
6	Engineering Technology at VSU	Engineering estimations and approximations – Chapter 5 Experiment#1 – Boiling of water	Coordinate Geom., Quiz#4 – Power and exponent
7	Team Work Exercise#2 – A new leaf	Dimensions, units and conversions – Chapter 6	Area and Volume, Quiz#5 – Coordinate geometry
8	Group Project – Bulk transporter	Dimensions, units and conversions – Chapter 6	Algebraic expressions, Quiz#6 – Area and volume
9	Fall break & Mid term grade	Test# 2 – Chapters 5 & 6	Algebraic equations, Quiz#7 - Algebraic expressions
10	Experiment#2 – Hydraulic bench	Analysis of problems – Chapters 9-13	Radicals, Quiz#8 – Algebraic equations
11	Individual Project#1 – Mouse trap	Analysis of problems – Chapters 9-13	Word problems, Quiz#9 - Radicals
12	Group Project discussion	Analysis of problems – Chapters 9-13	Quadratic equations, Quiz#10 – Word problems
13	Experiment#3 – Diesel engine	Test#3 – Chapters 9 -13	Word problems, Quiz#11 – Quadratic equations
14	Open	Analysis of problems – Chapters 9-13	Thanksgiving
15	Open	Analysis of problems – Chapters 9-13	Diagnostic test

Figure 1: Course schedule for Introduction to Engineering Technology for fall 2004



GEOMETRY IN SPACE

Complete the following (Be sure to include units).

1. length = 2 m
   width = 3 m
   height = 4 m

   Volume = ____________

2. radius = 10 cm
   height = 100 cm

   Volume = ____________

ALGEBRA AND EXPRESSIONS

Simplify.

1. 10r -6 + 2r = ________(let r = -2)

Solve for the unknown variable.

2. 8m – 9 = 31, m = ________

Complete the input-output table.

3. y = 3x - 4

x	y
-1	
0	
3	

Simplify each expression.

4. 7x + 2 + 4x -5 –x = ____________________

5. 4x + 3xy – 2x + xy -5 = __________________

ALGEBRA AND EQUATIONS

Solve for the unknown variable.

1. 11m – 8 = 6m + 28
   m = ______

2. 13x – 9 = 10x + 18
   x = ______

3. $\frac{x+14}{-4} - 2 = 7$
   x = _____

RADICALS

Solve the following radical expressions.

1. $\sqrt{2t-1} = 1$
   t = _____

4. (-15)(-4) = ______
5. (-3)(9) = ______
6. (-4)(-3)(-2) = ______
7. (-7)(-2)(3) = _____
8. $\frac{28}{-4}$ = _____
9. $\frac{-4}{-4}$ = _____

Write an inequality that compares the integers. Use =, <, >, ≤ or ≥.

10. -7 _____ -4
11. -11 ____ 10

POWERS AND EXPONENTS

Simplify or complete the following expressions.

1. $(10^{4})(10^{3})$ = ________
2. $(10^{-6})(10^{6})(10^{4})$ = ________
3. 0 .0234 = __________ x 10^{-3}

COORDINATE GEOMETRY

Write the appropriate quadrant for each ordered pair.

Coordinates	Quadrant
1. A (1, -5)	______________
2. B (-3, 5)	______________

What is the slope of the line that passes through the given points?

3. (1, 4) & (4,-5) slope = ________

Complete the following.

4. $y = \frac{3}{4}x + 10$ slope = _____ y-intercept = _______

MEASUREMENT

1 km = 0.621 mi. 1 mi = 1.609 km	1 L = 0.264 gal 1 gal = 3.785 L

Complete the statements. Use =, <, >, ≤ or ≥.

1. 12 gal ________ 50 L
2. 1.5 ft ____18 in.
3. 2 km ____ 5 mi

GEOMETRY IN PLANE

Complete the following for the right triangle, rectangle and circle shown below (include units).

1. 10in 26 in. 24 in.
   Perimeter =___________
   Area =___________

2. 8 m. 14 m
   Perimeter =__________
   Area = __________

3. D= 10 ft
   Perimeter = ________
   Area = _________

Figure 2: Examples from the mathematics diagnostic test administered to freshmen engineering technology students

to improve the post semester diagnostic scores by at least 10%. We plan to present detailed results from this diagnostic test in a future publication.

Component 1-Taught every Monday

The following topics were covered in component 1:

1. Introduction to the university, the department and the faculty
2. Introduction to engineering technology
3. How to succeed in school?
4. Introduction to Blackboard website for this course
5. Teamwork and projects
6. Engineering design process
7. Introduction to student organizations

For the first task, departmental faculty members were invited to the class and given an opportunity to share some information about themselves with the students. Afterwards, students were taken on a departmental tour to visit the electronics and mechanical laboratories. For the second task, a PowerPoint lecture was prepared using references [Eide, 1], [2] and [Cheshier, 3]. In this lecture, we cover the definition of engineering technology, differences between engineering and engineering technology, the distinction between various engineering principles, salary comparisons [4], etc. 'Studying Engineering Technology', [Cheshier, 2] was used to design a fifty minute lecture covering basic learning skills. This is very important because some of the students have poor study skills and weak academic foundations. We have included one homework assignment that required students to read about student success stories and determine the essential qualities that contributed to the success. It was our intention to help students to discover or realize the importance of goal setting and determination in their quest for a degree in engineering technology.

The Blackboard website for this course is currently being used for: posting course syllabus; posting assignments and solutions; posting practice problem for component 3; discussion board for students project work and to post mistakes in the text. Since most of our students are new to Blackboard, about thirty minutes are spent on getting them acquainted with this software and the website. They are required to self-enroll for this course at the Blackboard website.

Learning to work in teams is an essential part of any engineer's training. We start teaching students teamwork in the second week of the semester with a team exercise called 'El Nino' from Repario Ltd. In this exercise, the objective is to transport a slightly flexible bar from about hip height to a small platform that is about six inches from the ground (Figure 3). Students are made to stand in two rows, facing each other with each student supporting the bar on their index finger. While the bar is being lowered to the platform, each student must maintain contact with the bar at all times. If any student loses contact with the bar, they must shout "disconnect" and start all over. This exercise is deceptively complicated. Before the start of the exercise, all students were asked to brainstorm and write all the things they considered important for working in teams. This is followed by a ten to fifteen minutes discussion.

This teamwork exercise was conducted with two different groups this year, one with thirteen students and the second with nine students. It was observed that the smaller group had an easier time creating a positive work environment.

Figure 3: Teamwork exercise 1. Students lowering a flexible bar to a platform about six inches from the ground.

After a few failed attempts for the smaller group, one of the students emerged as the leader of the group. This student was able to direct the rest of the students to lower or raise the bar to successfully place it on the platform.

For the bigger group, after a few failed attempts, we had to ask the students to step away from the exercise and give the problem at-hand some thought before proceeding again. This helped, but they were still unable to accomplish the task in the allocated time. A discussion following this exercise gave students some further insight into teamwork. The key ingredients they outlined for a team's success are: listening, picking a leader, staying focused and cooperation with each other.

In the seventh week of the semester, we conducted another teamwork exercise called 'A New Leaf', also purchased from Repario Ltd. In addition to reemphasizing the elements of teamwork, this exercise also is a physical metaphor for change. The aim of this exercise is for all team members to stand on a carpet (supplied as a giant leaf) and then turn it over without stepping off it (Figure 4). Again, we noticed that smaller groups were able learn to turn the leaf over quicker than larger team. In this exercise though, all teams were successful. Each team had six to seven students. All teams were able to cut their time from 3 - 10 minutes for the first trial to less than 2 minutes by the second or third trial. Students picked a leader quicker than the 'El Nino' exercise, and seemed more willing to listen, and cooperate.

The main project for the freshman class this year is the American Society of Mechanical Engineers (ASME) design project, namely, 'Bulk Transporter'. Students have to design a remote controlled car that carries some rice, climbs three steps, turns 90°, goes down two steps and then downloads the rice into a container (more information about this project is available at www.asme.org). We have divided the class into five teams, each having a mix of electronics

Figure 4: Teamwork exercise 2. Students conducting a new leaf.

and mechanical engineering technology students. This project will be carried into the next semester in the second engineering technology course, ‘Introduction to Engineering Problem Solving’. In the first semester each team is required to write a proposal for their design including a cost breakdown. By the end of the semester, they are required to have purchased enough parts to make the transporter climb the first three steps of the platform. They are also required to make a presentation, using Microsoft PowerPoint, of their approach and progress-to-date in the last week of this course. In the sixth week of the second semester, each team will be required to have the full design ready for demonstration. The best two teams will go the regional ASME conference to compete against other schools.

The grades for each student for all group projects are based not only on team’s final solution or product, but also on the grades that their team members give them for that particular project. The assessment sheets from [Fletcher, 5] were used by students for team member evaluation. This ensures good participation in the project by all team members, or at least a better reward for students putting in majority of the work.

We try to get students to conduct a couple of individual hands-on projects during the semester. In the fall of 2004, the two individual projects were a mousetrap car and a glider project. In the mousetrap project, students had to design a car using a mousetrap. Examples of cars built by freshman are shown in Figure 5. The car that traveled the farthest was the winner. To make this more challenging, and to foster interdepartmental relationships, we had the freshman compete against students from other classes and other majors. In the glider project, students were required to build a device that would be dropped from about 25 feet. The score was a product of the time that the device stayed afloat and the weight of the device.

Figure 5: Examples of cars built by students using a mousetrap for an individual project.

Component 2-Taught every Wednesday

In this component we try to introduce the students to basic engineering principles. The main topics that are included in this component are: engineering design, representation of technical information, estimations and approximations, dimensions and units, mechanics (with main emphasis on vector algebra), simple electric circuits, conservation of mass and conservation of energy. Early in the semester, we introduce the engineering analysis format, to emphasize a logical and systematic approach to problem solving as outlined below:

1. Problem statement
2. Given
3. To find
4. Diagram
5. Assumptions
6. Solution
7. Conclusion

This method is taught through in-class and homework problems. After that, we try to take an approach where we combine experiments with theory to let the students analyze any engineering problem. For example, to explain the difference between precision and accuracy, we conduct an experiment that requires the students to collect data from a pot of boiling water. The class is divided in teams of three to four students. Each team is given a different instrument to measure water temperature over a period of 20 minutes. The four instruments that we use are:

1. Mercury thermometer measuring temperature in °F
2. Mercury thermometer measuring temperature in °C
3. Thermocouple measuring temperature in °C
4. Thermocouple measuring temperature in °F

The last thermocouple is intentionally adjusted to read incorrect temperature, e.g., reads 180 °F instead of 220 °F. All teams share their data with other teams, and are asked to rank the measurements from most precise to least precise, and from most accurate to least accurate. They are asked to use reference [1], and built in functions of average and standard deviation in Microsoft Excel to analyze the problem. Each team presents their results which is followed by a group discussion of accuracy and precision. We think taking this approach has improved the student's understanding of the difference between precision and accuracy, especially the data from the last thermocouple because, in spite of it being most inaccurate, it turns out to be 2nd most precise.

To teach students data presentation, in another experiment, students collected data from a diesel engine. Data was collected for fuel consumption and exhaust temperature as a function of revolutions per minute. Students were required to use Microsoft Excel to create graphs to present their observations for this experiment. Another experiment that we use in this class is a hydraulic bench for teaching the concept of volumetric and mass flow rate. We are in the process of adding an experiment from electricity. Our goal is to convey all topics for component 2 using experiments.

Component 3-Taught every Friday

Component 3 is math remediation. As discussed in the "Diagnostics Test" section of this paper, the topics covered in this component are based on the deficiencies revealed in the diagnostic test. The methodology that we are trying to follow is:

1. Spend 40 minutes on Friday in week A covering topic x
2. Practice problems are posted on a webpage from topic x for students to practice
3. In first 10 minutes of week B, a quiz from topic x is administered to the students. In the next 40 minutes, topic y is taught and the procedure is repeated every week.

The last column in Figure 1 gives a general overview of the topics covered each week in this component.

Grading Policy

Each component carries 1/3rd weight for this course. For component 1, the main project is worth 70%, followed by the two individual projects, and class participation accounting for the rest of the grade. In component 2, homework is worth 20%, tests are worth 40%, and a final comprehensive test is worth 40%. In component 3, quizzes are worth 80% of the grade, while the remaining 20% is for the post semester diagnostic test.

CONCLUSIONS AND FUTURE WORK

Although this course is still being refined, and it is too early to tell, there are visible improvements in time management, discipline and motivation level of the students. Also, improvement in student's basic math skills is evident from the 10% increase in the post semester diagnostic test scores.

We will closely monitor the efficacy of component 3 in improving the fundamentals of mathematics of our students. The progress of this approach will be monitored and modifications will be made as required. We plan to publish the particulars of the diagnostic test, along with detailed test results after compiling data from at least two more semesters.

In agreement with our philosophy of making this course more hands-on, another ongoing task is the inclusion of more experiments. In the next two semesters we plan to introduce the topics of Ohms law, conservation of mass, etc., through experiments. Another task that we are trying to accomplish is putting all the quizzes for component 3 in an electronic format on the courses webpage. This should make the grading process easier for the instructor.

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Biographical Information

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Sandeep Ahuja, an Assistant Professor of Mechanical Engineering Technology at Virginia State University, received his Ph.D. in Mechanical Engineering in 1994 from Drexel University, Philadelphia, PA. He worked in the industry for seven years before becoming a faculty member at VSU in 2002. His research interests are in the area of applied and basic research in combustion, and education related innovations. He is also the ASME faculty advisor.

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