Development of Engineering Applications of Algebra and Trigonometry Laboratory Course for Engineering Technology Students

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Abstract

Solid foundation of math for engineering technology majors is very essential for success in upper level Engineering Technology courses. Assessment of TAC ABET program outcomes for several upper level engineering technology courses has indicated inadequate understanding and preparation of algebra and other math topics. Most of the time while presenting several math topics in a traditional math course, its relationship with engineering applications is not clearly presented. This creates a fear about math courses and as such students tend to keep distance from it. The perfunctory approach by the students affects them in the longer run.

To address this problem a College-wide unified approach was decided. Three 1 credit hour laboratory courses for application of Algebra & Trigonometry, Calculus-I and Calculus-II were developed. The objective for development of these courses is to help students to improve understanding of math topics, build solid foundation, and develop interest in engineering and engineering technology career. Secondary effect of performing better in engineering major courses due to well preparedness in pre requisite math topics is also anticipated.

In the laboratory course for Algebra & Trigonometry during regular semester students perform experiments based on selected topics from algebra and trigonometry. Experiments include measurement of volume of various shapes, flow rate, velocity, acceleration, observing physical phenomenon changing exponentially/logarithmically, and solving simultaneous equation of moving bodies.

Focus in these experiments is on applications of math and not the engineering concepts. The relevant engineering concepts are learned by the students in upper level courses. This course is primarily designed for engineering technology majors; however few engineering and computer science majors register for Algebra & Trigonometry course and are required to sign up for this lab. These students have to take Algebra & Trigonometry before getting admitted to Calculus-I. In this paper we present the Engineering Laboratory I for Math – Algebra & Trigonometry consisting of several experiments and their relationship with topics from algebra trigonometry. Assessment plan is designed to evaluate the success of this course.

Introduction

Solid foundation of math for engineering technology majors is very essential for success in upper level Engineering Technology courses. Assessment of TAC ABET program outcomes for several upper level engineering technology courses has indicated inadequate understanding and preparation of algebra trigonometry and other upper level math topics. Most of the time while presenting several math topics in a traditional math course, its relationship with engineering applications is not clearly presented. In many cases no assignments on application in engineering are included in the syllabus. This creates a fear amongst students about math courses and as such students tend to keep distance from it. The perfunctory approach by the students affects them in the longer run.

Initial investigation of reasoning for lack of covering applications in math courses revealed few genuine situations. These include unavailability of laboratory facilities, insufficient experience of engineering applications by mathematics faculty, lack of time for covering additional application topics, and over crowded classes. There might be similar or more experience at other universities. We are not aware of any campus developing any similar laboratory courses.

College Unified Approach

Engineering Technology majors take Algebra-Trigonometry, Calculus-I, and Calculus-II as math requirement, where as all Engineering majors take Calculus-I, Calculus-II, and Advanced Math for Engineers. The Computer Science majors require Calculus-I and Calculus-II as their math requirement.

A comprehensive approach was taken by the college to address this problem and a sequence of three one-credit hour laboratory courses was developed. Since these are beneficial to all majors in the College of Engineering at Prairie View A&M University, a general engineering prefix is used (GNEG) for all courses. The Engineering Laboratory I for Math – Algebra & Trigonometry is numbered as GNEG1111. Similar courses for Calculus-I and Calculus-II are also developed and are numbered as GNEG1121 and 2021 respectively. A team of six professors from various departments was formed to develop these courses during summer 2008. Various topics were identified for each lab course and sets of creative experiments were designed.

Engineering Technology Curriculum

The engineering technology degree requirements were modified to accommodate these changes. Before the implementation (2007-2008) Engineering Technology requirements were 135/136. At that time two separate 3 credit hour courses for Algebra and Trigonometry were required. In the new degree plan a 5 credit hour Algebra & Trigonometry course with new 1 credit hour lab add to 6 hours and do not yield any burden. However two one credit hour lab courses for Calculus-I and Calculus-II increase the total by 2 credit hours. At the same time 4 hours second Chemistry course with its lab was decided to be removed and technical elective requirement was reduced from 11 to 8 credit hours. Thus the total number of hours in the 2008-2009 degree plan reduced to 130/131. Figure 1 shows the pre 2008 and post 2008 math sequence for engineering technology majors.

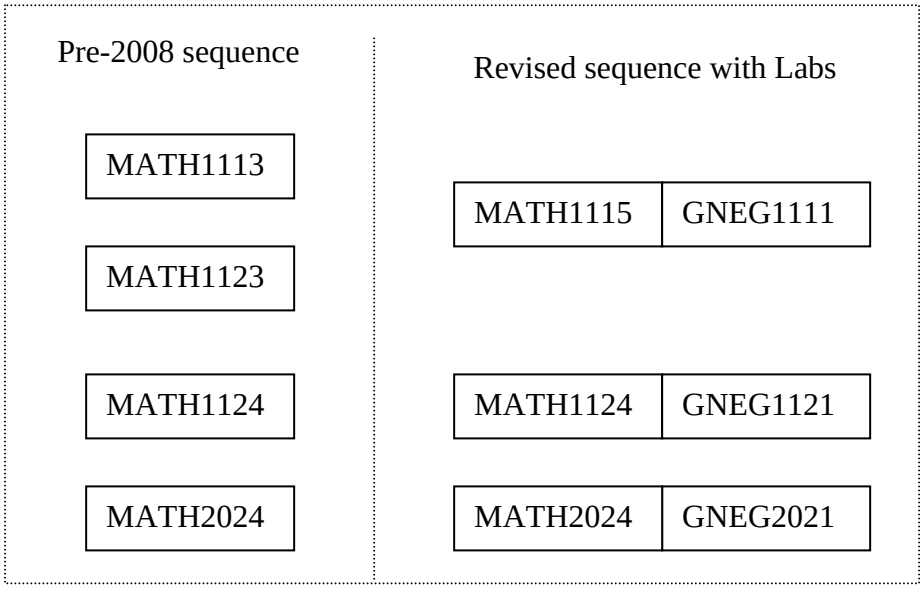

Figure 1 Pre-2008 and revised sequence of Math courses for engineering technology

New Laboratory Course

Based on the topics covered in the MATH 1115 Algebra Trigonometry course and the text book[1] following areas in math were identified for development of experiments. Each lab is described with students' activity in that particular lab. Duration of each laboratory experiment is 2 hours and class meets once a week. Typical lab consists of pre-lab quiz, power point presentation, review of relevant math topic, handout of procedures, and actual experiment. Usually student finished all the work during the 2 hours and there was very little homework assigned.

The course objectives are: (i) to develop students' interest in engineering, technology, and computer science major fields, (ii) to understand and perform better in the math foundation courses, and (iii) to be better prepared for upper level engineering courses. Indirectly we are addressing the problem relating to retention and graduation.

List of experiments

1. Observing and developing equations / Volume of Pizza
   Linear equations, Volume equations and graphs

   Using play dough students were asked to form various pizza shapes and calculate their volumes. Flexible plastic loops of different heights were provided.

2. Volume, height, and flow rate

Students calculated volumes of cylindrical containers. Volumes of tapered cups were determined using tap water and calibrated cylinders. Same set up was used to find the flow rate from the tap. Student also watched a video clip of a car dashboard displaying instantaneous MPG, Average MPG and Speed. Student determined the gas consumption in Gallons per hour

3. Quadratic Functions
   Identifying quadratic equations and establishing relation to parabolic functions.

4. Exponential Functions

   Students were asked to find the piano key – frequency relationship of a piano, in other words determine the musical scale. Plotting the frequency versus key number revealed exponential function. Students observed the exponential decay of capacitor voltage with time.

5. Logarithmic Functions

   Logarithmic relations were observed using EXCEL log scale plots. Students were asked to use data on frequency from lab 4 to generate semi log plots.

6. Trigonometric Functions / Volume of a tapered Cup/Height of Water Tower.

   Students were asked to find the height of tower based on angle – distance measurements and applying trigonometric functions learnt in the math class.

7. Applications of Trigonometric Functions / Motion of a Projectile

   Students used Computer animation program developed for motion of a projectile to understand the relationship between range, velocity, and angle.

8. System of Equations

   Students used graphical approach to solve simultaneous equations for multiple linear motions. The animation program used in motion of projectile is again utilized to explain the linear and parabolic processes meeting at the target.

End of the Semester Survey

At the end of the semester, the following students' opinion survey questionnaire was used.

1. I found the laboratories interesting
2. GNEG1111 gave me more engineering application examples in math
3. The hands-on experiments increased my interest about engineering
4. I believe the laboratories will help me in my future major related courses

5. I would like to see more math topics explained in engineering application

The numerical averages of the responses ranged between 3.4 and 3.7. However, real assessment of the achievement of the goals can not be done during this first time offering. These preliminary results are by no means claim of success or short comings. Once these students take upper level courses we will follow their progress and then can make some conclusions.

Summary

In summary, we developed a laboratory courses for engineering applications of Math. Specifically this paper describes the one for algebra and trigonometry. Students developed interest in their major field and get better prepared with math foundation. Students enjoy animation computer simulation and game type experiments while applying underlying math to various engineering problems. Numerical averages of the opinion survey yielded high values, however real assessment of the achievement of the goals could not be done during this first time offering.

Reference

1. Mark Dugopolski, 'College Algebra and Trigonometry' 4th Edition, With MyMath Lab

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