Integrating Engineering into TI-83 Math Education Course

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Abstract

North Carolina A&T State University is a recipient of a National Science Foundation Planning Grant for "Bridges for Engineering Education". As a part of the initiative, the Engineering and Education faculty are working together to enhance the exposure to engineering concepts for pre-service and in-service teachers. The first course identified for this effort was Technology and Applications in Secondary School Mathematics, a graduate course primarily taken by in-service teachers with a desire to enhance their students understanding of the materials through hands on activities with the TI-83 calculator.

The paper illustrates how engineering concepts have been integrated into a graphing calculator course and sparked new interest and collaborations between engineering and education faculty as well as the math teachers in Guilford County. The partnership has great potential for exposing several middle and high school students to the practices of the engineering profession.

Introduction

In the Fall of 2001, North Carolina A&T State University established an Academy of Teaching and Learning to enhance the learning process for all students on campus and to provide students with the foundation to become more effective instructors. Key teachers from each of the units through out the campus were charged with this task and met on a regular basis to develop programs and activities for the entire campus. One of the notable growths out of this effort was a partnership between an Engineering and a Math Education faculty member. Through this partnership and the creative effort that both faculty members brought, the idea was borne for a class that would increase the awareness of engineering concepts and how best to incorporate them into high school math classes through the use of the TI-83 calculator. The TI-83 calculator was selected because it is the dominant calculator used in Guilford County's algebra courses.

Overview

The course developed was offered as a graduate level Math Course. It is designed to discuss the techniques of teaching Pre-Algebra, Algebra, Geometry, Pre-Calculus, Calculus and other secondary mathematics using calculators, calculator based labs and other technology. Primary focus was placed on the TI-83 calculator and the TI-92 hand held computer and how best to integrate its functions into the Middle School Algebra curriculum. Specific objectives were:

1) To develop teacher's familiarity with the use of the TI-83+ calculators in teaching function based algebra
2) To instruct teachers in the exploration/investigation mode of teaching secondary mathematics
3) To enhance participants understanding of the content and pedagogical approach to teaching and learning mathematics with graphing calculator technologies.
    i. Use of tools (TI-83+, TI-92 and the CBL2/CBR2 systems)
    ii. Mathematical modeling, including data gathering and analysis
4) To experience significant problems situations that take advantage of the use of technology as a tool for learning
5) To assist teachers in gaining the confidence to use new technology strategies and lessons as they incorporate the use of technology in their class room
6) To prepare teachers to teach middle and high school mathematics using the TI-83+ graphing calculator and the TI-92 hand held computer

Method

There has been much discussion in recent years on how best to teach mathematics and how to associate math with the derived sciences (physics, engineering). In the past math was often taught in a vacuum. Philosophies were presented and students recited them, principles were "taught", but many times without the students being able to apply them to any real life situation. Math was presented in such complex ways that students were often discouraged from pursuing careers that would require strong math backgrounds. Math educators in the U.S. recognized this was a problem and in the 1980's they embarked on a movement to improve the way math is taught. The primary goal was to extend instructions beyond rote learning by tying in real life lessons that give the students the ability to visualize the concepts, and as such improve their retention and understanding. An out come of such an approach would be to given the correct activities, the students would be encouraged to explore math, to use their imagination and think about Mathematics.

Teachers were first taken through a series of introductory exercises that allowed them to become familiar with the calculator/hand held computer and its functions. These exercises demonstrated some of the basic principles in engineering. The idea here was to introduce the engineering concepts using the algebra they were already familiar with, by considering some real world applications, provide visualization and then create specific examples. Once the teachers were sufficiently proficient in using the calculator and it's basic functions, they were given assignments that would encourage them to find a way to incorporate the algebra in their curriculum with the functions they were taught. Below is a table that compares the old teaching methods with the new.

OLD STANDARDS	NEW STANDARDS
Competitive Environment	Cooperative Environment
Technology use not permitted	Technology for exploration and computation
Follow the rules	Justify thinking and explore
The right way	Alternate approaches
Look for clues	Think about the problem
Paper/Pencil	Physical Material
Teaching by telling	Learning by doing
Topics in isolation	Topics in relation (real life application)
Teacher talks	Student discussions
Individual responsibility	Activity among students

Example: When teaching the algebraic concept of logical multiplication one can easily integrate the engineering theories associated with probability and as such can use the calculator to demonstrate the ideas of permutation and combination to help the student better grasp the concept. In doing this, the student is also able to see a real life situation in which they would apply factorials, which is another topic they would have covered in Algebra.

Step One: Present a real life application:

How many different 7 digit telephone numbers can be derived if any digit from 0 to 9 can be used but no digit may appear more than once.

Step Two: Provide the visualization:

There are 10 different ways to chose the first digit but since no digit may appear more than once there are only 9 ways to select the second, 8 to select the third and so on. Therefore the number of 7-digit phone numbers that can be made without repeating is: 10 x 9 x 8 x 7 x 6 x 5 x 4 x 3 x 2 x 1 = 604,800.

Step Three: Associate with the engineering concept:

This specific example demonstrates one aspect of probability: Specifically the idea of permutation. The equation that represents permutation is:

$${}_nP_r = \frac{n!}{(n-r)!}$$ where n= the number of digits we have to select from and r = the number of different digits to be combined thus for our example:

$$\frac{10!}{(10-7)!} = \frac{10!}{3!} = \frac{3628800}{6} = 604800$$

Once the fundamental is understood the instructions are delivered on how to compute factorials on the TI-83 calculator.

Results

Once basics like this were covered the teachers were asked to create lessons that would incorporate more Science/Engineering concepts while using their calculators. Below are a few overviews of some of the projects/activities presented by the teachers:

Project /Activity Name: Kaboom

Objectives [as identified by the teacher]: 1) Demonstrate an understanding of patterns, relationships and other fundamental algebraic concepts. 2) Demonstrate an understanding of Data collection, probability and data analysis (graphs).

Scientific Principles: Speed/Velocity, Slopes, Projectile, Probability, Linear Regression

Overview: Using a Nerf ball, PVC tubing and isopropyl alcohol, this experiment will demonstrate how a chemical reaction can create enough power to send an object flying into the air.

By varying the angle from which the ball is launched the student will study the impact of the angle on distance. The data collected (angle and related distance, height etc.) the student will learn how to create scatter plots and do linear regression using the TI-83 calculator. Here the student is given a practical application for the slope intercept form y=mx+b.

Project/Activity Name: Enjoy a classic

Objectives: 1) Develop their number sense, numerations skills and numerical operations.
2) Develop their spatial sense, practice measurements and geometry.

Scientific Principles: Surface Area, volume, measurement, metric/standard conversion

Overview: Using a 12-ounce coca cola can compare how much/less material would be used if the dimension of the can was changed.

By changing the proportions of the can the students were able to see the relationship between surface area and volume and to understand more about the concepts of equivalent measures. By graphing the change in proportions and surfaces are students can visualize the relationship between surface area and volume.

Conclusion

The course was successful in introducing the idea of incorporating science into the math curriculum. The teachers were able to shift teaching paradigm and in making this shift, provide the students with the arena to become more creative in their approach to math and mathematic applications in real life.

The teachers were able to successfully produce multiple activities that allowed them to incorporate more science and engineering principles into their regular class schedule. These

activities provided them with the opportunity to introduce the calculator and other technology as learning aids. Their goal to create an atmosphere that fosters imagination and extrapolation through real life applications and visualization was actually achieved.

This is just a tiny fraction of the possibilities that exist when the resources between engineering and education are joined. The ultimate goal is to provide in-service and pre-service teachers with sufficient training to engender their own creative process so they can change their paradigm and the way they deliver their math material to their students. Below are some of the teacher's feedbacks about the class:

1. Liked the hands on approach to using the TI-83 and using it for statistical analysis, data collection and measuring.
2. Got fresh ideas for creating lesson plans.
3. Assignments were challenging new and interactive.
4. Learned how to use the TI-83 calculator and how to incorporate its use into lesson plans

Bibliography

Committee for Economic Development, "Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Foundation", Washington D.C.: Committee for Economic Development 1995

Erwin, B., "K-12 Education and Systems Engineering: A New Perspective", Proceeding of the 2001 American Society for Engineering Education Annual Conference, Abuquerque NM, June 2001, Session 1280 CD-ROM

Biography

TRACY A. EVERS
Tracey is in the last semester of her Master's in Electrical Engineering at North Carolina A&T State University. Upon completion of her Masters requirements she will begin the Ph.D. program. While her research focus is on Power Engineering and controls it is her intention to pursue a career a professor.

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Eric teaches electrical engineering and focuses his primary energy on engineering education and student retention issues. He has been chosen Teacher of the Year in EE for four of his seven years at A&T. He is an active member of ASEE. He received BS degrees in Electrical Engineering and Mathematics from Carnegie Mellon University and MS and Ph.D. degrees in Electrical Engineering from Howard University.

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Gilbert is the Assistant Vice Chancellor for Summer Sessions and Outreach at North Carolina A&T State University. He is actively involved with mathematics education and student retention issues. He received his BS and MS degrees in Mathematics Education from north Carolina A&T State University and his Ph.D. from Pennsylvania State University also in Mathematics Education.

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