

# Work in Progress - Motivation for Mathematics, Using Design with the Wright State Model

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**Abstract** - The first iteration of a freshman “Applying Mathematics to Engineering Design” Course at Oklahoma State University was based on the successful national model of a Freshman Engineering Math course designed at Wright State University. This course is addresses issues in transfer of mathematics to engineering, motivation, and retention. The course introduces engineering applications to algebra, linear algebra, trigonometry, sinusoids, differentiation, and integration through the use of laboratory design experiences. Students who participated in this course completed several validated assessments including a mathematics attitude survey and concept inventory. Students who completed this course had higher motivation towards and continuing in engineering as compared to a control group of other freshman engineering students. No statistically significant differences were found on the concept inventory in either group.

*Index Terms* - Freshman, Mathematics, Design, Engineering

## INTRODUCTION

Since students are leaving engineering disciplines for other majors, strategies are being developed to help motivate students to remain in engineering. To address retention, Oklahoma State University partnered with the National Engineering Mathematics Consortium at Wright State University [1]. The goal of this national dissemination Course, Curriculum, and Laboratory Improvement (CCLI) project is to engage freshman in a course that demonstrates how engineers use math. In the fall of 2008 a new course was created for freshman electrical and chemical engineers; students in other disciplines also enrolled.

The course, based on the Wright State model [1], additionally included design topics taught through a series of hands-on projects. The course attempts to tackle low transfer of mathematics to engineering courses by having freshman learn how mathematics is applied to engineering design problems. Topics covered in the course include algebra, linear algebra, trigonometry, sinusoids, differentiation, and integrals. With the exception of algebra, each topic consisted of two labs lasting two hours each. In the first of the two labs, students acquired data and used both analytical mathematics and MATLAB to analyze the data. During the second week, students used the analyzed data to design or improve the design of the experimental

system. Details on the mathematics topics and hands-on laboratory exercises will be given in the presentation. In this, the first iteration of this course, validated assessment instruments were used to measure changes in student learning and attitudes including an attitude survey [2] and a concept inventory [3]. Two sections of a traditional Introduction to Engineering course were used as a control. The one hour Introduction to Engineering courses teach basic skills such as using Microsoft Office software, library use, and elements of engineering ethics. Since instructors volunteer to teach this course, the content varies greatly between sections.

## COURSE TOPICS

As mentioned previously, the course contextualized algebra, linear algebra, trigonometry, sinusoids, differentiation, and integrals in an engineering design framework. Most of the labs were based on the Wright State model, however the trigonometry, linear algebra, and calculus labs were re-designed to focus on electrical and chemical engineering concepts. Students, divided into teams of 4 or 5, were on the same team the entire course.

In a newly developed trigonometry lab, students designed a refractometer to measure the index of refraction of various concentrations of sugar in water. The students measured the angle of a laser entering a tank of water then measured the point where the laser hit a ruler on the other side. Using Snell’s Law, the students calculated the index of refraction of the liquid as a function of concentration. The students determined the dimensions for a smaller refractometer design after completing this lab.

Similarly, in the linear algebra lab, the students measured the transmittance of a liquid. The liquids consisted of a solution of blue colored water, a solution of red colored water, and then two mixed solutions of water created from the two solutions. The students were given cuvettes with a red LED attached to one side and a CdSe photocell attached to the other side. The cuvettes were painted black in order to keep ambient light from perturbing the results. The students measured the resistance of the photocell as the different solutions of liquid were inserted into the cuvette. During the design portion of this lab, the students were required to reverse engineer an unknown mixed concentration of the pure solutions. Then using the mixed solutions they had to come up with a way to mix the same concentrations as the unknown solution.

The calculus (differentiation and integration) labs used a robotic vehicle developed at Oklahoma State University as a tool to teach freshman level students [4]. The students had two challenges to complete. The first challenge, to demonstrate applications of differentiation, was to program the car to accelerate as fast as possible on a slick surface and a regular hallway floor. The students then used MATLAB to import the distance data from the car and differentiated to calculate the velocity and acceleration. From this students were able to determine the optimum acceleration profile to cover a distance in the shortest period of time. The second test was a crash safety device; the students designed an attenuator that would slow down the car to a safe speed before crashing into a wall. The students then imported the acceleration data from the car into MATLAB and integrated the acceleration to find the speed of the car before it hit the wall. The deceleration profile was measured in order to determine the effectiveness of the safety devices.

### DATA ANALYSIS

The students who participated in this course were required to complete a pre and post attitude survey, and a pre and post mathematics concept inventory. The control group took the pre and post mathematics concept inventory, and a post attitude survey.

The mathematics concept inventory focused on two parts; algebra and calculus. The total number of students who took the test was  $N=62$ . This was broken into the following groups the new course  $N_S = 27$ , the control group  $N_C = 35$ , female students  $N_F = 9$ , and male students  $N_M = 53$ . Pre and post test results were analyzed using analysis of covariance. Although both sample and control groups performed better on the post test, the difference is not significant. The control group did significantly better (by ten points on a 100 point scale), than the sample group. Since students self-enrolled in the course it is likely students who needed more remedial help in mathematics chose the course described here. Students in both groups performed significantly better on the algebra portion of the test than the calculus portion, which may reflect the fact algebra questions were procedural while calculus questions were conceptual. There were no statistically significant differences for gender, but the number of female students in the class was small. From initial results it appears that students who did well on the algebra questions did better on the calculus questions; i.e. algebra scores predict calculus scores. The change in scores from pre test to post test were greater for the engineering mathematics course, but not at a statistically significant level.

The mathematics attitude survey was given as a pre and post survey to the students in the Applying Mathematics to Engineering Design course. The students in the control group were given the survey as just a post survey. The total number of students who took the survey was  $N=57$ , with the control group  $N_C=30$ , and the new course  $N_S=27$ . The survey had 25 questions; the questions were broken up into the following categories: intrinsic motivation, pre-conceived

notions about mathematics and engineering, motivation to continue mathematics, and another category that had questions that didn't fit with the rest in mathematics. Analysis of variance shows that for all categories the control group had a significantly lower mean ( $p < 0.05$ ) than the sample, indicating that the new course had a positive impact in all categories.

### FUTURE WORK

When this course is again taught in the fall of 2009 several changes will be made based on results of the above analysis. Further changes were suggested through the observations of the course by a doctoral student from OSU's College of Education. The labs will be reduced in length in order to shorten the time it takes to complete each lab to one hour rather than taking a full two hours that the lab is scheduled. The first iteration the course had too many assignments, and the work load of the students has been decreased as well. From the results on the pre and post tests it may be that validated concept inventory for calculus may not be an appropriate test due to poor performance on this examination. Since the course is designed to show the students how engineers use mathematics existing tests are not appropriate and the authors will develop a test that measures a student's ability to solve engineering problems.

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