

Implementing an Engineering Applications of Mathematics Course at the University of Arkansas

Kellie Schneider, Heath Schluterman, Ph.D., and C. Richard Cassady, Ph.D.
University of Arkansas, kellie@uark.edu, hschlut@uark.edu, cassady@uark.edu

Abstract – One of the primary factors associated with retention of first-year engineering students is their performance in their first math class. Due to recent changes in math placement guidelines coupled with unprecedented growth in the College of Engineering, many students in the Freshman Engineering Program at the University of Arkansas begin their course of study one math class behind Calculus I. An Engineering Applications of Mathematics course has been developed, accepted by the Department of Mathematical Sciences as a prerequisite for the Calculus I course, and offered to a total of 271 students. In addition, the number of students entering the program two math classes behind Calculus I has increased significantly as well. Therefore, a pilot course that will prepare these students for Calculus I their second semester has been developed.

Index Terms – engineering applications of mathematics, first-year retention, math placement

INTRODUCTION

The Freshman Engineering Program (FEP) in the College of Engineering (CoE) at the University of Arkansas (UofA) was established in 2007 to improve the retention of first-year engineering students to the sophomore year. This goal supports the long-term retention and graduation rate goals of the CoE. The FEP is executed via two sub programs: the Freshman Engineering Academic Program and the Freshman Engineering Student Services Program. The activities associated with both the Academic Program and Student Services program are intended to improve the academic success of our students and to increase their motivation to persist in engineering study.

One of the primary factors associated with retention of first-year engineering students is their performance in their first math class [1]. The FEP Academic Program calls for students to begin their course of study in Calculus I. However, recent changes in math placement requirements coupled with unprecedented growth in the FEP cohort size have resulted in a significant number of students beginning their academic career in a math class below Calculus I (the first math class to count towards the engineering degree at the UofA). In this study, we are particularly interested in students that begin their first-year of study one math class behind Calculus I.

MATH PLACEMENT

Math placement at the UofA is determined by the Department of Mathematical Sciences (DMS) and is based primarily on a student's performance on the math portion of either the ACT or the SAT. Students may also submit transfer credit for prerequisite courses or complete an optional math placement test to improve their initial math placement. The math placement test is comprised of a series of three exams. The first test is the UA Preparedness for Algebra (PALG). The second test is the UA Mastery of College Algebra (MALG), and the third test is the UA Preparedness for Calculus (PCALC). Students receive three attempts at each test, and the testing software includes a built-in, personalized study guide based on test results. The current math placement guidelines are shown in Table I below.

TABLE I
CURRENT UOFA MATH PLACEMENT GUIDELINES

MATH COURSE	ACT/SAT MATH SCORES	MATH PLACEMENT TEST
CALCULUS I	30/680	PCALC 80% AND MALG 80% AND PALG 80%
PRECALCULUS	26/600	MALG 80% AND PALG 80%
COLLEGE ALGEBRA	23/540	PALG 80%
COLLEGE ALGEBRA WITH REVIEW	19/460	PALG 70%

The optional math placement test was first offered in the summer prior to the 2010-2011 school year. Previously, math placement was based only on a student's performance on math ACT or SAT scores unless he or she submitted transfer credit for the pre-requisite courses. The placement guidelines prior to 2010 are shown in Table II below.

TABLE II
PREVIOUS UOFA MATH PLACEMENT GUIDELINES

MATH COURSE	ACT/SAT MATH SCORES		
	2007-2008	2008-2009	2009-2010
CALCULUS I	26/600	26/600	27/610
PRECALCULUS	23/540	23/540	23/540
COLLEGE ALGEBRA	19/460	20/470	22/520
COLLEGE ALGEBRA WITH REVIEW	N/A	N/A	19/460

In addition to the changes in math placement set forth by the DMS, the UofA has experienced unprecedented growth since the inception of the FEP. Table III shows the cohort size and math placement for FEP students since 2007.

TABLE III
FEP COHORT SIZE AND MATH PLACEMENT PERCENTAGE

	2007	2008	2009	2010	2011
COHORT SIZE	343	419	385	518	693
CALCULUS II AND HIGHER	80	128	105	165	187
CALCULUS I	156	186	152	116	141
PRECALCULUS	69	25	90	149	249
COLLEGE ALGEBRA	22	25	21	81	87
BEGINNING ALGEBRA	6	12	17	7	10

The changes in math placement requirements as well as the increased cohort sizes have resulted in a significant number of students beginning their academic career in a math class below Calculus I. Prior to the 2010-2011 school year, approximately 70% of FEP students began their course of study in Calculus I or higher. However, that percentage dropped to approximately 50% after the requirements for entry into Calculus I were significantly increased. As a result, the faculty in the FEP decided to implement a program to motivate these students to persist in engineering while preparing them for Calculus I. Initially, these efforts focus on students that begin their study one math class behind Calculus I.

ENGINEERING APPLICATIONS OF MATHEMATICS

The issues associated with students beginning their course of study “behind” in the Calculus sequence are not unique to the FEP. In fact, The Engineering Applications of Mathematics (E-Math) course at the UofA is modeled after a similar course developed by the faculty at Wright State University [2]. The UofA catalog description of the E-Math course is given as:

Overview of the mathematics topics heavily used in sophomore-level engineering courses. Topics include algebraic analysis, trigonometry, vectors and complex number, sinusoids and harmonic signals, systems of equations and matrices, differentiation, integration, and differential equations. All topics motivated by engineering applications. Usage of mathematical analysis software is emphasized.

I. Fall 2010 and Spring 2011 Offerings

The first E-Math course was offered as a three credit hour course (with optional drill sessions) to a group of 51 students in Fall 2010 followed by an additional group of 31 students in Spring 2011. These students were required to pass the math placement tests administered by the DMS to gain access into Calculus I. The grade distribution and subsequent math course for these students are shown in Tables IV and V. Note that several students that completed the E-Math course in Spring 2011 elected to take math courses over the summer and transfer credit for required prerequisites.

II. Fall 2011 and Spring 2012 Offerings

After the initial offerings of the E-Math course, the FEP faculty restructured the course by increasing the number of credit hours from three to four and making the drill mandatory. This resulted in the E-Math course having a similar structure to Precalculus as well as the courses in the Calculus sequence.

TABLE IV
FALL 2010 E-MATH GRADE AND SPRING 2011 MATH COURSE

COURSE	E-MATH GRADE				
	A	B	C	D	F
COLLEGE ALGEBRA	0	0	1	0	0
PRECALCULUS	2	7	3	0	0
CALCULUS I	2	26	0	0	0
OTHER	0	2	1	0	0
NONE	1	3	0	1	0
DID NOT RETURN	0	1	1	0	0
TOTAL	5	39	6	1	0

TABLE V
SPRING 2011 E-MATH GRADE AND FALL 2011 MATH COURSE

COURSE	E-MATH GRADE					
	A	B	C	D	F	W
COLLEGE ALGEBRA	0	0	0	0	1	0
PRECALCULUS	0	1	1	1	1	1
CALCULUS I	0	3	2	1	0	0
CALCULUS II	0	1	2	1	0	0
CALCULUS III	0	0	1	0	0	0
OTHER	0	0	1	0	0	1
NONE	0	0	2	1	3	0
DID NOT RETURN	0	0	1	2	2	1
TOTAL	0	5	10	6	7	3

Since its inception in 2007, the FEP has established and maintained an excellent working relationship with administrators in the DMS, and in the summer of 2011, the DMS agreed to allow students earning a grade of C or better in E-Math to advance directly to Calculus I. The reasons for doing this were two-fold. First, because of our established relationship, the DMS trusted the FEP faculty to deliver a course that contained the appropriate content and rigor to prepare students for the Calculus sequence. Second, this reduced the number of students taking their Precalculus course and allowed the DMS to use those resources in other areas.

In Fall 2011, a total of 107 students enrolled in E-Math, and 62 students earned a grade of C or better. The grade distribution and subsequent math course for these students are shown below in Table VI. During the Spring 2012 semester, a total of 82 students enrolled in E-Math, and 37 students earned a grade of C or better. Since students from the Spring 2012 offering may elect to take transfer courses over the summer, the information on Fall 2012 math course is not yet available.

TABLE V
FALL 2011 E-MATH GRADE AND SPRING 2012 MATH COURSE

COURSE	E-MATH GRADE					
	A	B	C	D	F	W
COLLEGE ALGEBRA	0	0	0	0	1	3
PRECALCULUS	0	0	0	2	1	6
E-MATH	0	0	0	1	5	1
CALCULUS I	21	21	18	2	1	1
OTHER	1	0	1	0	0	0
NONE	0	1	1	1	1	1
DID NOT RETURN	0	1	2	3	3	7
TOTAL	22	23	22	9	12	19

III. Fall 2012 Offering

In Fall 2012 at least one section of E-Math will be offered for students that begin their course of study one math class behind Calculus I. In addition, the FEP faculty are launching a pilot program aimed at students that begin their course of study two math classes behind Calculus I. Up to this point, the course of action for these students has been to take College Algebra in the first semester and either Precalculus or E-Math in the second semester. This leads to disadvantages in both the first and second years of the students' progression. Many students that successfully progress through the math sequence (College Algebra in the Fall and Precalculus or E-Math in the Spring) will have not completed Calculus I or University Physics I prior to the beginning of their sophomore year. Thus, these students lack the pre-requisites for many (possibly all) of the courses in their chosen engineering field. In addition, many of these students have exhausted their University Core requirements. The result is students feel disconnected from the College of Engineering as they are no longer a part of the FEP and not eligible to enroll in CoE courses.

This Fall, a new program exists which would allow highly motivated students who qualify for placement into College Algebra to take concurrent courses of College Algebra and E-Math during the first semester. An instructor from the DMS will work closely with the FEP faculty to develop course materials for these combined courses. The College Algebra course will meet for fifty minutes twice each week and require additional computer-based assignments outside of class. The E-Math lecture will meet for eighty minutes twice each week and the associated drill will meet for an additional fifty minutes twice each week. Since the courses will be integrated, the emphasis of the course will change throughout the semester. In the early part of the semester, the class time will focus primarily on College Algebra topics. As the semester progresses, class time will become more balanced between the two courses. By the end, class time will be primarily focused on E-math topics.

Students will receive separate grades for the College Algebra and E-Math courses and cannot receive a higher grade in the E-Math course than they receive in the College Algebra course. Students will also have the option of withdrawing from the E-Math portion of the course without removing themselves from the College Algebra portion. As

with the students taking individual versions of these courses, students who pass the E-Math course with a C or better will be qualified for Calculus I. Students who pass only the College Algebra portion will be qualified to take E-math or Precalculus the following semester.

By allowing students to progress through the math sequence at a quicker pace, the hope is that they can stay connected with the CoE and continue towards graduation. FEP will monitor this progress by comparing the progression and success of students in this course through the math sequence, their retention in the CoE, and ultimately their graduation rates.

FUTURE WORK

Student retention in engineering, progress through the engineering curriculum, and graduation rates are being collected. We will investigate this data and compare the retention, progression, and graduation rates of students that participate in the E-Math program.

REFERENCES

- [1] Cassady, C.R. and S. Mulvenon, "Initial Analysis of Freshman-To-Sophomore Retention in a New First-Year Engineering Program", *Proceedings of the 2009 ASEE Annual Conference & Exposition*, Austin, TX, June 2009.
- [2] Klingbiel, N.W. et. al. "Rethinking Engineering Mathematics Education: A Model for Increased Retention, Motivation and Success in Engineering." *Proceedings of the 2004 ASEE Annual Conference & Exposition*, Salt Lake City, Utah, June 2004.

AUTHOR INFORMATION

Kellie Schneider Instructor of Freshman Engineering, University of Arkansas, kellie@uark.edu

Heath Schluterman, Ph.D. Instructor of Freshman Engineering, University of Arkansas, hschlut@uark.edu

C. Richard Cassady, Ph.D. Director of the Freshman Engineering Program and Professor of Industrial Engineering, University of Arkansas, cassady@uark.edu