Advances in Engineering Education

SUMMER 2010

Integrated Engineering Math-Based Summer Bridge Program for Student Retention

JIM GLEASON
Department of Mathematics
University of Alabama
Tuscaloosa, Alabama

KAREN BOYKIN
Alabama Experimental Program to Stimulate Competitive Research
Normal, Alabama

PAULINE JOHNSON, LARRY BOWEN, KEVIN WHITAKER, CELINA MICU, DHEERAJ RAJU AND CARTER SLAPPEY
University of Alabama
Tuscaloosa, Alabama

ABSTRACT

In an effort to reduce the engineering student withdrawal rate due to mathematics, The University of Alabama developed a unique, informal, interactive, and interdisciplinary five-week summer residence program called the Engineering Math Advancement Program (E-MAP). The program aims to increase retention by preparing students to be successful in calculus and excited about engineering. In addition to a nontraditional math class, the program includes hands-on "Living-Lab" experiences, field trips and a community service project led by professional engineers. The non-math aspects of the program strengthened mathematical skills indirectly through engagement of the students in laboratory and real world engineering problems, in the idea that solving skills are best nurtured through hands-on experiences. E-MAP improved retention of students in STEM fields overall by approximately 12% after three years with 36% increase in retention of students who entered with placement scores within the target math range for the program.

Keywords: Retention, Bridge Program, Mathematics

INTRODUCTION

During the 1980s and 1990s, the number of undergraduates in engineering programs was in a significant decline ([7]; [13]) as can be seen in Figure 1. Because of this decline, a large portion of the engineering workforce is nearing retirement age. Since the number of engineering jobs has

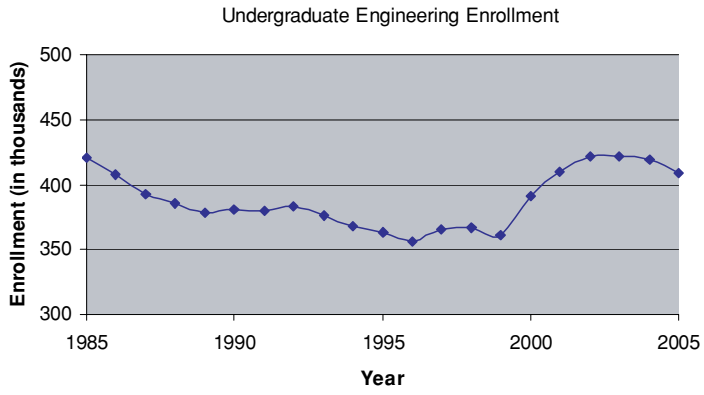

Figure 1. Undergraduate Engineering Enrollment [7], [13].

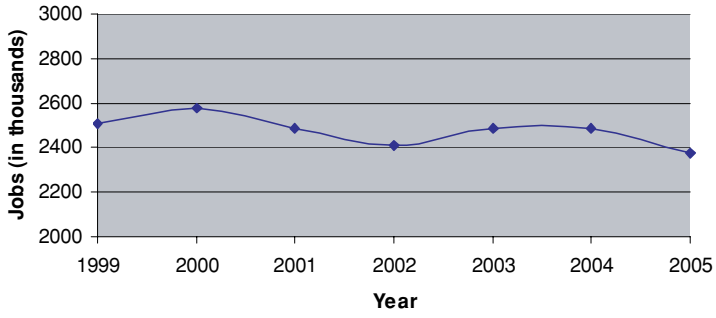

Figure 2. Architecture and Engineering Employment Estimates [5].

remained stable during recent years (as can be seen in Figure 2), a larger number of individuals with engineering degrees is necessary in the near future. While the engineering enrollment numbers have increased in the past few years ([7]; [13]), increased recruitment and retention of undergraduate students in the field of engineering is critical.

In an effort to increase the engineering workforce, the National Science Foundation has funded programs designed to improve the recruitment and retention of undergraduate engineering students through the Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP). At The University of Alabama, these program funds focus on the retention of incoming freshmen who have declared engineering as their major.

Since the mathematics requirements of the engineering majors is an area that causes many students to drop out of engineering, the core of the program focuses on mathematics preparation. This

mathematical preparation involves non-traditional classes in pre-calculus and calculus concepts designed to take incoming students who place in a pre-calculus class and improve their mathematical knowledge so that they are able to start their calculus sequence in the fall. In addition to the core mathematics content of the program, the students also participate in physics and chemistry classes as well as hands-on engineering activities and fieldtrips to introduce the students to various engineering fields.

LITERATURE REVIEW

Importance of Mathematics to Success in Engineering

Math is one of the primary tools of engineering. The earlier the student learns to master the tool, the better he/she can manage the tool and apply it to problem solving. Lack of preparation in math is one of the main factors contributing to student dropout in Engineering at The University of Alabama. The UA student retention statistics showed that less than 33% of incoming engineering freshmen remained through graduation. This is 19 points lower than the national average of 52% for similar programs. Analyses indicate the primary reason for low retention is an inability of incoming freshmen to perform well in first-year calculus classes [11].

Studies at UA have established that around 60–70% of entering freshman engineering students are not calculus ready ([11]; [25]). Since the engineering program of study at UA assumes calculus ready students, 70% of entering freshmen engineering students are under-prepared for the program due to deficiency in mathematics. The main results of this are poor performance in math related engineering classes, longer time to graduation and low graduation rates from engineering.

Calculus courses are fundamental to the engineering curriculum as they provide a strong base for future engineering courses. Therefore, success in calculus is important to success in engineering [9]. Many research studies support the fact that freshman students entering engineering program lack the ability to progress through the calculus sequence ([3]; [17]; [18]). Furthermore research indicates that students entering into current engineering programs do not have the ability to solve multistep problems, and lack higher order thinking skills necessary to solve engineering problems. They have also not developed a questioning attitude necessary for the fundamental understanding of the meaning behind many concepts presented. These important skills are required at all levels of the curriculum to enhance success in engineering [8].

Programs Designed to Improve the Situation

A study on the effects of mathematics courses taken by students at the junior and high school level showed that the number of mathematics courses plays a prominent role in higher-level

mathematics achievement [22]. A number of successful programs address the deficiencies in entering freshmen preparedness for the engineering curriculum.

The Emerging Scholars Program (ESP), one of the oldest intervention programs developed in the 1970's, has been adapted in mathematics courses at several major universities. These programs offer workshops which help freshman students build necessary mathematics background and develop the skills required to be successful in engineering [2]. Students who attended a "summer calculus bridge program" for engineering freshmen at the University of Missouri in Rolla showed significantly higher performance than their counterparts who did not attend the program [1]. A similar engineering mathematics retention program at Wright State University included a freshman level engineering mathematics course replacing traditional math prerequisite requirements. This program improved overall success in student grades and motivation and helped improve student retention [10]. In another study, at-risk freshman engineering students who participated in a supplemental program received higher course grades and had higher retention rates [23].

The one week mathematics bridge program at Purdue allows students to discover strengths and weaknesses and improve preparation in mathematics. This program was one of the most effective pre-college retention programs offered by the schools of engineering [4]. Other bridge programs were 10 weeks long and the participants received course credits for participation. Many of the programs offered were free of charge and included scholarships [15].

Another engineering retention program at the University of Maryland tried to 'bridge' the gap between high school preparation and expected standards of engineering freshman majors. This program focused on improving academic success and included life-skills, with social and motivational components. The students who attended this program benefited largely in terms of settling down and dealing with first semester [12].

PROGRAM DESCRIPTION

When students first arrive at The University of Alabama (UA), they take a mathematics placement exam, designed by the Department of Mathematics, which determines the mathematics course in which they may enroll. This initial placement has a strong correlation with student engineering retention rates. Historically, students scoring below 310 on the Math Placement Test do not have the math skills needed to pursue a career in engineering and only account for less than 10% of the engineering graduates. For students with math placement scores between 310 and 440, retention is also low due to their math skills not being at the level that allow them to succeed in engineering math based courses with these students accounting for nearly 40% of the students who drop out

of engineering. Although not as significant, retention is a problem in the higher scoring group, with the main reasons being unchallenging initial mathematics courses and lack of motivation to continue in the pursuit of a career in engineering [11].

To combat this deficiency in mathematics knowledge, UA developed a unique, informal, interactive, and interdisciplinary summer residence program called the Engineering Math Advancement Program (E-MAP) to prepare incoming freshmen for calculus. While some bridge programs such as the one at Purdue [4] are as short as one week, the E-MAP program was designed as a five-week program in part so that the students have time to learn the pre-calculus material rather than simply have a brief refresher of material that they already know, but have quickly forgotten. Additionally, the five-week period allows for the inclusion of components focusing on academic and life skills following the model of the University of Maryland [12], other content areas students struggle with such as Physics, and hands-on engineering labs and field trips in order to motivate the students to remain in engineering.

In addition to a nontraditional math class, the program includes hands-on "Living-Lab" experiences, field trips and a community service project led by professional engineers. These non-math aspects of the program strengthened mathematical skills indirectly through engagement of the students in laboratory and real world engineering problems, in the idea that solving skills develop best through hands-on experiences ([16]; [19]).

The E-MAP program is tuition-free, the only cost for the student being food and on-campus accommodation. Scholarship is also available for up to 30% of the participants based on their needs. Although entering freshmen students are not required to participate in the E-MAP program, they are strongly encouraged to do so. The recruitment for the program involves an intensive mailing campaign and high school advising. Promotional material includes program flyers, poster presentations, a program web site, and program advertisements on the university and College of Engineering websites.

The E-MAP program specifically targets the 60% of students entering the College of Engineering who have math skills which place them into the pre-calculus range (placement scores between 310 and 440). Normally, these students would enroll in Math 112 (Pre-Calculus Algebra) and 113 (Pre-Calculus Trigonometry), or Math 115 (Pre-Calculus Algebra and Trigonometry), placing them in either case a year behind the remaining 30% entering at the Engineering Calculus 125 level. Up to an additional year is required to get back on track with the core engineering courses. Because the lower 10% in incoming students only have a 10% chance of graduating with an engineering degree, these students do not create a large enough pool to justify a program targeted toward them. The upper 30% consist of engineering students ready for calculus and are therefore also outside the scope of the E-MAP program (Figure 3).

E-MAP Objectives and Metrics

The E-MAP program revolved around the following primary goals.

- Improving engineering students' success rates in their first mathematics course taken at the university.
- Increase the number of engineering students initially placed into higher mathematics courses.
- Improve the first, second, and third year retention rates for engineering students.
- Improve the 5-year graduation rates for engineering students.

In order to measure the success of the first goal, grades in the first mathematics course for E-MAP and non-E-MAP engineering students will be compared using a t test for related samples on their grade with an A given a 4, A- a 3.67, a B+ is equivalent to 3.33, and so on. We measure the increase in the number of engineering students placed into higher mathematics courses with a comparison of pre and post mathematics test data to measure the increase in mathematics ability from the program as well as the number of students who placed into a higher mathematics course. The student retention rates are compared using a binomial test with $p < 0.05$.

E-MAP Structure

The program includes a variety of experiences to enhance math skills and student engagement in engineering. The engineering related activities include hands-on "Living-Lab" experiences, field trips and a community service project led by professional engineers. In addition, the incorporated fun learning experiences, teambuilding and social activities help avoid summer burn-out and encourage participation and bonding. The mathematics classes are primarily in the mornings with the afternoons allocated by rotation to Living-Labs, Calculus Lab, and Community Service Project.

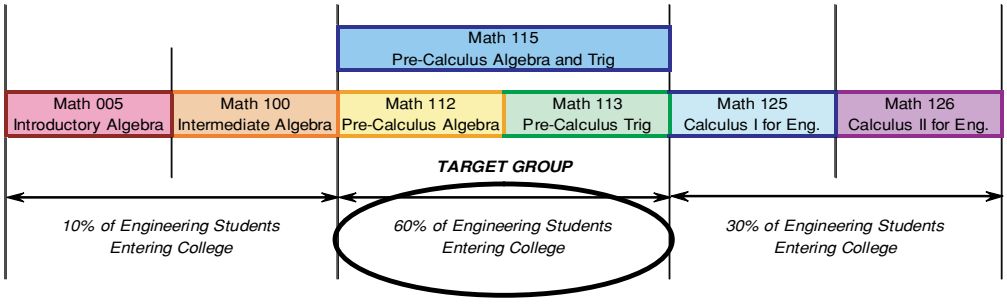

Figure 3. E-MAP Target Group Related to Math Placement Score at UA.

One day per week is reserved for the learning experience through the field trips. Social activities and/or math tutoring are available in the evenings.

Math Class

Following the models set forth by other programs, ([1]; [2]; [10]; [23]) the E-MAP program's primary focus is to improve the mathematical preparation of incoming engineering students. Similar to the program at Wright State [10], the E-MAP program offers an alternative curriculum for pre-calculus math building upon the principle that students are individuals with different learning styles. The structure of the E-MAP math program provides time for individualized mentoring experiences that could not take place in the traditional lecture classroom because it involves learning using multi-media introduction of new material, one-on-one tutoring, and hands-on experience with applications. The classroom model has a small student/teacher ratio with a lead instructor assisted by two teaching assistants. Students are in the classroom learning pre-calculus algebra and trigonometry for two hours per day with nearly all of the standard semester pre-calculus concepts taught during the program.

In order to help the students understand the concept of odd and even functions, the students were given a set of coordinates and told to stand at the appropriate location on the classroom grid formed using the floor tiles. The students then reflected themselves over the y-axis, the x-axis, and across the origin. This activity led to further discussions about inverse functions by having half the class model the graph of a function and the other half reflect about the line $y = x$.

The math class incorporates relevant math concepts from the program's engineering labs and service projects. One of the projects in the math class explored exponential functions through a cooling experiment. The students poured boiling water into various containers and measured the temperature every minute. They then plotted points, drew the graph, and determined what type of function modeled the behavior.

Additionally, tutoring sessions are available in the afternoon and evening. At these sessions, the classroom teaching assistant interacts within the groups to explain and reinforce concepts. In class testing including a final exam determines if E-MAP students are calculus ready.

Living Laboratory

The Living Laboratories involve the eight areas of engineering at UA and run in multiple blocks to keep student-instructor ratios low and to allow flexibility in scheduling. Each student is required to take four three-hour labs. Students may select three out of nine offered laboratories, the fourth one being assigned by the program coordinators based on student interest and lab availability.

One example of such a project is an activity which takes the students out to a local lake to test the water temperature and turbidity at various depths. See Figure 4.

The two primary objectives of the laboratories are: the use of math skills in an engineering setting, student exposure to the practical side of each engineering discipline. The application of math skills in engineering is experienced, for example, by exposing students to "data-gathering" experiments in each laboratory, data is then used to examine, explain, or derive basic engineering theory. The second objective is achieved by giving "broad-picture" engineering problems to illustrate the thought process behind each step of engineering analysis, and to design and teaching students how to break large, complicated projects down into small manageable pieces. This is an opportunity for the departments to immerse the students in the "hands-on" work within each field and assists the student in career selection and development.

Field and Campus Trips

One day per week is dedicated to exposing students to off-campus engineering practice such as plant and project tours. The field trips, usually a day long, focus on one or more engineering career fields. We believe that the field trips will facilitate student exposure to potential employers

Figure 4. Testing water samples for temperature and turbidity.

by providing introductions and promoting interactions between students, key industry, government representatives and decision makers. Societal impact events were conducted to educate students on engineering responsibilities. An effort has been made to line up effective speakers, demonstrations and interactive exhibits at the plant sites so that students are engaged rather than just observers.

Campus tours of local interest sites were interwoven with presentations by key freshman program personnel to assist with orientation information including registration and housing. Societal and campus activities were held in the afternoons on days where no laboratory components were conducted.

Community Service Theme Project

The societal benefit component introduces students to participate as "team engineers" on real-world projects sponsored by the West Alabama Chamber of Commerce's Environmental Task Force. The "Chamber Project" addresses how to research a project, how to work as part of an engineering team, and the thought process in tackling a large engineering problem. The Chamber members were extremely impressed with the student's presentations and their interaction with local engineers. They asked for continued sponsorship of E-MAP as a Chamber outreach program and have helped to advertise activities with the local press. Year two incorporated a real world societal benefit project for the creation of a "theme park" in the Lake Tuscaloosa area. Problems related to the various design aspects were reiterated and reinforced in various program components.

Figure 5: Field trips to Hale County Revitalization Organization and Nucor Steel plant

RESULTS

Improved Mathematical Knowledge

To measure the effectiveness of the E-MAP program at improving the students' mathematical knowledge, students completed the mathematics placement exam before arriving for the summer program and at the conclusion of the program during year 2 and 3. The E-MAP students showed an increase (mean (M) = 54, standard deviation (SD) = 50.8) in their mathematics placement score. This increase was statistically significant, $t(46) = 7.30$, p = 0.0000, two-tailed. (Note that all tests for statistical significance are at the $p < 0.05$ level.) The majority (58%) of the participants who were eligible to improve their mathematics placement did so with some of the participants moving two or three classes ahead of their original placement.

Therefore, E-MAP is successful at improving the participants' mathematical knowledge and allowing the participants to begin their college education at a higher level within the mathematics curriculum. This leads to the question of if this increased initial placement within the curriculum reflects a shortening of their undergraduate program by removing one or two mathematics courses.

Success in First Mathematics Course

As a way of measuring the goal of increasing the E-MAP participants' ability to succeed in mathematics courses, the success rate of the E-MAP students was compared to the overall success rate of incoming engineering students with similar mathematics placement exam scores in their mathematics courses during their first semester at the university. As seen in Figure 6, the E-MAP students actually performed worse than did their counterparts in all except the calculus course during fall 2007.

In the fall 2006 course work the control students in Math 112 (College Algebra without Trig) had higher weighted GPA grades ($M = 2.39$, $SD = 1.48$) than the E-MAP students ($M = 0.71$, $SD = 1.25$). This difference was significant, $t(64) = 2.86$, $p = 0.0057$, two-tailed. In Math 115 (College Algebra with Trig), the control group ($M = 2.43$, $SD = 1.32$) outperformed the E-MAP group ($M = 1.134$, $SD = 1.25$), and the difference is statistically significant, $t(73) = 2.91$, $p = 0.0048$, two-tailed. For Math 125 (Calculus I), the difference between the control group ($M = 2.37$, $SD = 1.51$) and the E-MAP group ($M = 1.56$, $SD = 1.57$) was not statistically significant, $t(90) = 1.78$, $p = 0.0785$, two-tailed.

For the fall 2007 course work, in Math 112 the control group (M=2.50, SD=1.14) outperformed the E-MAP group ($M = 0.67$, $SD = 1.15$), with the difference being significant, $t(18)= 2.55$, $p = 0.0201$, two-tailed. However, in Math 115 the control group ($M = 1.64$, $SD = 1.30$) and the E-MAP group ($M = 1$, $SD = 1.55$) had no significant difference, $t(61) = 1.13$, $p = 0.2629$, two-tailed. For Math 125 there was no difference between the control group ($M = 2.53$, $SD = 1.36$) and the E-MAP group ($M = 2.67$, $SD = 1.41$), $t(60) = -0.26$, $p = 0.7958$, two-tailed.

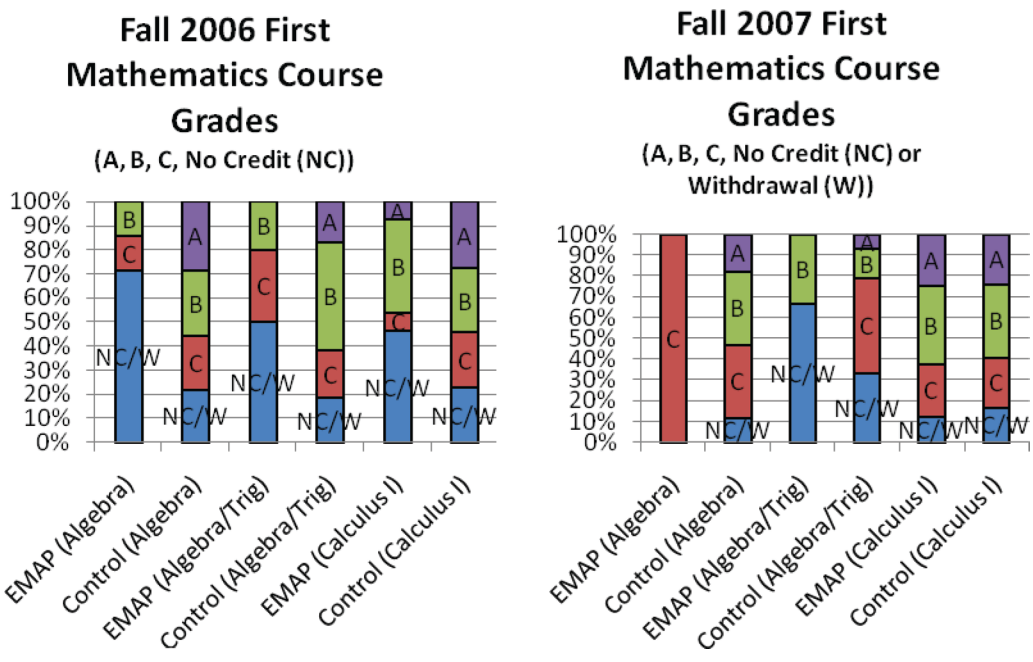

Figure 6. Success in First Mathematics Course.

Therefore, the courses where the grades in the first mathematics course were statistically significant was in the College Algebra without Trig and the College Algebra with Trig courses in the fall of 2006 and the College Algebra without Trig in the fall of 2007. All other courses provided no statistically significant differences even though the control group consistently outperformed the E-MAP group. In particular, those students who placed into calculus, and therefore were the successful participants in the program, performed at statistically the same level as the engineering students who placed into calculus without the summer bridge program.

One hypothesis to explain the phenomenon that the E-MAP students performed poorer during their first mathematics course relates to the nature of the mathematics placement exam. Incoming freshmen traditional take the mathematics placement exam during their summer orientation. This implies that the exam is usually measuring the mathematical content that the students know when they have not studied mathematics recently. The mathematics course placement of the E-MAP students resulted from their performance on the exam after recently completing a program designed to improve their scores on the mathematics placement exam. This means that the two populations placed into their mathematics courses under different criteria.

Another hypothesis involves the E-MAP program working as a filter to determine which incoming students whose mathematics placement is below calculus will likely succeed in engineering. Since the mathematics placement exam likely measures the mathematical ability of students, those students who place into Math 112 after 5 weeks of intensive mathematics review of all subjects on the exam are most likely much weaker mathematically than those students who placed into Math 112 not having studied mathematics for a few months prior to taking the exam. Hence they had lower passing rates. However, for those students who succeeded in improving their mathematics placement into calculus likely had the knowledge necessary to succeed in calculus but simply needed a quick refresher of the pre-calculus material as demonstrated by the improved success of those students placing into calculus.

Retention

One focus of the program goals is to enhance student retention within STEM fields. The data suggests that the program is accomplishing this objective. Tables below are comparing the individual data sets with the data parsed by program year.

The pilot program of 2005 was tracked for retention over the past three years along with the programs for 2006 and 2007. The first sub-grouping shows a comparison between those E-MAP students scoring between 310 and 440 (the program target group) on the math placement test and those non-E-MAP students in the same range. Student third-year retention in STEM areas of E-MAP students was 91.77% for this subgroup compared with only 63.2% of the general STEM students. A binomial test revealed that there is a significant difference, $z = 2.05$, $p = 0.0202$. When restricted to those retained in engineering, there is no significant difference, $z = 0.95$, $p = 0.1711$.

Examining the entire 2005 E-MAP class, student retention was just over 78% in STEM fields at the end of the third year compared to just over 66% for the control group which is not significantly different, $z = 1.18$, $p = 0.1190$. Similarly there is no significant difference in retention in engineering programs for this group, $z = 0.05$, $p = 0.4801$. First year retention in all cases with E-MAP students was 100% compared to upper 90's for non-E-MAP students.

For the 2006 class, the second year retention numbers were not significantly different for either the STEM retention, $z = -1.11$, $p = 0.1335$, or the engineering retention, $z = -0.97$, $p = 0.1660$.

E-MAP improved retention of students in STEM fields overall by approximately 12%. Note that student status was broken down into those (1) remaining in engineering, (2) leaving engineering and STEM areas, and those (2) leaving engineering but remaining in other STEM areas. This was determined by (A) UA enrollment or (B) direct survey of student if they left the University. A small portion of the students, less than five, which had left the university and were no longer at known addresses were assumed to have left engineering based on their GPA upon leaving.

		E-MAP STUDENTS			Non-E-MAP STUDENTS		
Class	*Category*	*First year Retention*	*Second Year Retention*	*Third Year Retention*	*First year Retention*	*Second Year Retention*	*Third Year Retention*
2005 Class MPT Score 310 to 440	STEM	100.00%	100.00%	91.77%	97.60%	79.20%	63.20%
	EG	91.67%	83.33%	75.00%	97.60%	78.40%	61.60%
	Non-STEM	0.00%	0.00%	8.33%	2.40%	14.40%	20.80%
	Drop Out	0.00%	0.00%	0.00%	0.00%	6.40%	16.00%
	Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Whole 2005 Class	STEM	100.00%	91.30%	78.26%	95.02%	79.10%	66.67%
	EG	95.65%	82.61%	65.22%	95.02%	78.11%	64.68%
	Non-STEM	0.00%	4.35%	17.39%	4.48%	13.43%	19.40%
	Drop Out	0.00%	4.35%	4.35%	0.50%	7.46%	13.93%
	Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Whole 2006 Class	STEM	100.00%	73.33%		99.13%	81.22%	
	EG	100.00%	73.33%		99.13%	80.35%	
	Non-STEM	0.00%	23.33%		0.44%	12.23%	
	Drop Out	0.00%	0.00%		0.44%	6.55%	
	Total	100.00%	100.00%		100.00%	100.00%	
Whole 2007 Class	STEM	100.00%			97.45%		
	EG	100.00%			97.45%		
	Non-STEM	0.00%			2.55%		
	Drop Out	0.00%			0.00%		
	Total	100.00%			100.00%		

Table 1: Retention Analysis Results (Percentage remaining in category after each time period)

DISCUSSION

While the students' success in their first mathematics class following E-MAP did not match the goals set for the program, the overall goal of improving student retention was achieved. This mixed result might cause one to question the strength of the correlation between a student's first college mathematics grade and graduation likelihood. This study therefore implies that researchers should focus as much on the social network aspects of summer bridge programs as the academic since these social aspects and the learning community that developed as a result may be the largest contributing factor to keeping students in engineering.

Another conclusion of this study is that the goal of changing a student's initial mathematics course placement might cause the student to have a lower grade in that higher mathematics course. This would imply that these secondary to college bridge programs might focus on the goal of improving the students' mathematical knowledge in order to improve their chances of success in their first mathematics course rather than accelerating their program. At the same time, these programs

should also focus on increasing their social connections with other students in the same situation to facilitate the creation of a community of learners that is strongly correlated with student retention and success.

ACKNOWLEDGEMENT

The current paper is greatly improved through comments of the reviewers. This project is supported by the Science, Technology, Engineering and Mathematics Talent Expansion Program (STEP) at the National Science Foundation (NSF) Program, DUE 0431668. Any conclusions or recommendations stated here are those of the authors and do not necessarily reflect official positions of NSF.

REFERENCES

[1] Allen, L., 2001. *An evaluation of the University of Missouri-Rolla minority engineering program 7-weeks summer bridge program*. Unpublished doctoral dissertation. Rolla, Missouri.

[2] Asera, R., 2001. *Calculus and community: A history of the emerging scholars program*. New York: The College Board.

[3] Barrow, D L, and S A Fulling, 1998. *Using an integrated engineering curriculum to improve freshman calculus*. American Society of Engineering Education: Seattle. (http://soa.asee.org/paper/conference/paper-view.cfm?id=14109).

[4] Budny, Dan, 1995. "Mathematics bridge program." Frontiers in Education. Atlanta.

[5] Bureau of Labor Statistics, 2008. Employment and Wage Estimates from http://www.bls.gov. Washington, DC: US Department of Labor.

[6] Burge, L., 2004. Direct Communication, Pre-Engineering Summer Camp, Tuskegee University.

[7] Engineering Workforce Commission, 2006. *Engineering & Technology Enrollments, Fall 2005*. Washington, DC: American Association of Engineering Societies.

[8] Fowler, D A, D. A. Maxwell, and J. E. Froyd, 2003. "Learning strategy growth not what expected after two years through engineering curriculum." *ASEE Conference Proceedings.* Nashville, Tennessee. (http://soa.asee.org/paper/conference/paper-view.cfm?id=19039)

[9] Gainen, J, and E. W. Willemsen, 1995. *Fostering student success in quantitative gateway courses (New Direction for Teaching and Learning)*. San Francisco: Jossey Bass.

[10] Klingbeil, N W, R E Mercer, K S Rattan, M L Raymer, and D B Reynolds, 2006. "Redefining engineering mathematics education at Wright State University." American Society for Engineering Education. (http://soa.asee.org/paper/conference/paper-view.cfm?id=1833)

[11] Knight, A., 2003. Data Collection and Analysis from 1997 through 2004 of Engineering Student Placement and Performance Tests, Class Evaluations, and Personal Data.

[12] Nagchaudhuri, A, and G. Singh, 2001. "Summer engineering bridge program at the University of Maryland Eastern Shore: Objectives and enrichment activities." American Society for Engineering Education Annual Conference and Exposition. (http://soa.asee.org/paper/conference/paper-view.cfm?id=16436)

[13] National Science Board, 2008. *Science and Engineering Indicators 2008*. Two Volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A).

[14] Northwestern University, 1999. EXCEL Summer Program, Integrated Science Program, Newsletter.

[15] Reichert, Monty, 1997. "Taking another look at educating African American engineers." *Journal of Engineering Education* 86, no. 3: 241–253.

[16] Resnick, L., 1991. Shared cognition: Thinking as Social Practice. In: Resnick, L.B., Levine, J.M. and Teasley, S., Editors, 1991. *Perspectives on Socially Shared Cognition*, Washington, DC : American Psychological Association, 1–10.

[17] Sathianathan, D, S Tavener, K Voss, S Armentrout, P Yaeger, and R Marra, 1999. "Using applied engineering problems in calculus classes to promote learning in context and teamwork." *Frontiers in Education*: 12-14.

[18] Seymour, E, and N M Hewitt, 1997. *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview.

[19] Scanlon, E., C. Colwell, M. Cooper, and T. Di Paolo, 2004. Remote Experiments, Reversioning and Rethinking Science Learning, *Computers & Education*, 43(1-2), 153-163.

[20] The University of Alabama Website http://registrar.ua.edu/enrollment/

[21] U.S. Department of Education. National Center for Education Statistics. http://nces.ed.gov/programs/digest/d05/tables/dt05_211.asp

[22] Wang, J, and P Goldschmidt, 1999. "Opportunity to learn, language proficiency and immigrant status on mathematics achievement." *The Journal of Educationcal Research* 93, no. 2 : 101-111.

[23] Webster, T J, and K C Dee, 1998. "Supplemental instruction integrated into an introductory engineering course." *Journal of Engineering Education* 87, no. 4: 377-383. (http://www.asee.org/publications/jee/PAPERS/display.cfm?pdf=567.pdf&special_issue=567)

[24] Wood, S., 1998. Red Shirt Program. College of Engineering, University of Alabama in Birmingham.

[25] Wood, S., 2004. Freshman Program Data Analysis. College of Engineering, University of Alabama at Tuscaloosa.

AUTHORS

Jim Gleason received a Ph.D. in mathematics from the University of California, Santa Barbara and is currently an Assistant Professor of Mathematics Education in the Department of Mathematics at The University of Alabama. In addition to working on improving the transition from high school to college mathematics, he conducts research involving the measurement of the specialized mathematical content knowledge for teaching.

Pauline Johnson is an Associate Professor of Civil Construction and Environmental Engineering at the University of Alabama and co-PI of the NSF-STEP grant that funded this study. In addition to research on retention of engineering students her other areas of current research areas are in, service learning, the graduate learning experience, water and wastewater treatment, alternative energy systems and sustainable development.

Karen Boykin serves as the Research Education Outreach Director for the Alabama Experimental Program to Stimulate Competitive Reserach (ALEPSCoR) and Co-Director of the Environmental Institute. Dr. Boykin established the first statewide ALEPSCoR research education outreach initiative, the AEOI, a collaborative of the seven Ph.D. granting institutions in the state, post-secondary education 2 and 4-year non Ph.D. granting institutions, private sector industry representatives, and the State Department of Education along with several K-12 school districts. She received a B.S., M.S., and Ph.D. in engineering from the University of Alabama, an M.C.P. in Community Planning from Auburn University, and a J.D. from the Birmingham School of Law in 1997.

Larry Bowen received his Ph.D. in Applied Statistics from the University of Alabama. He is the Associate Director of the Center for Teaching and Learning at the University of Alabama and an adjunct in the UA Department of Mathematics. He was a member of the original project team that received a Pew Learning and Technology Program Grant to establish the Mathematics Technology Learning Center at the University of Alabama and he is UA Faculty-In-Residence in the Parker-Adams Freshman Living-Learning Community.

Kevin W. Whitaker is currently the Associate Dean for Academic Programs in the College of Engineering at The University of Alabama. He has been a member of the UA faculty since 1987. Dr. Whitaker obtained his B.S. in Mechanical Engineering from General Motors Institute, a MS in Mechanical Engineering from Texas A&M, and a Ph.D. in Aerospace Engineering also from Texas A&M University. His professional research interests are in the areas of applied artificial intelligence, propulsion system inverse design and optimization and hypersonic aerodynamics.

Celina Micu is a graduate student at The University of Alabama, Tuscaloosa working on her Ph.D. degree in Environmental Engineering with minors in Water Resources and Statistics. She received a Bachelor of Science degree in Geography (minor in Hydrology) from the "Babes-Bolyai" University of Cluj-Napoca, Romania in 2001. She is currently working as student program coordinator for Engineering Math Advancement Program combining administrative and teaching duties. Her research interests include the magnitude of impervious surfaces in urban watersheds, the distribution of the contaminants produced by different land uses, and heavy metals in stormwater.

Dheeraj Raju completed his master's degree in industrial engineering and is currently working on his Ph.D. degree in educational research at The University of Alabama.

Carter Slappey is an undergraduate student at The University of Alabama majoring in Finance. He participated in this project as part of the Computer Based Honors program at The University of Alabama.

Address correspondence to:
Jim Gleason
Department of Mathematics
Box 870350
The University of Alabama
Tuscaloosa, AL 35487-0350
jgleason@as.ua.edu