AC 2012-5020: THE WRIGHT STATE MODEL FOR ENGINEERING MATHEMATICS EDUCATION: HIGHLIGHTS FROM A CCLI PHASE 3 INITIATIVE, VOLUME 3

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The Wright State Model for Engineering Mathematics Education: Highlights from a CCLI Phase 3 Initiative, Volume 3

Abstract

The inability of incoming students to advance past the traditional first-year calculus sequence is a primary cause of attrition in engineering programs across the country. As a result, this paper will describe an NSF funded initiative at Wright State University to redefine the way engineering mathematics is taught, with the goal of increasing student retention, motivation and success in engineering. Since its inception in Fall of 2004, the Wright State model has had an overwhelming impact on the retention and success of engineering students at Wright State University, from first-year through graduation. As part of a 2008 NSF CCLI Phase 3 initiative, various aspects of the Wright State model are now under pilot adoption and assessment at a total of 15 institutions across the country. The last two years' papers have highlighted progress at a subset of the Phase 3 institutions, including the details of their diverse implementations and a preliminary assessment of their results. This year's paper (Volume 3) will highlight progress at three additional institutions, each of which has brought a novel perspective to the Wright State approach.

Introduction - The Wright State Model for Engineering Mathematics Education

The traditional engineering curriculum requires at least one full year of calculus as a prerequisite to core sophomore-level engineering courses. However, the inability of incoming students to successfully advance past the traditional first-year calculus sequence plagues engineering programs across the country. As such, there is a drastic need for a proven model which eliminates the first-year mathematics bottleneck in the traditional engineering curriculum, yet can be readily adopted by engineering programs across the country. The expansion and assessment of one such model is the focus of this work.

The Wright State model begins with the development of a novel first-year engineering mathematics course, EGR 101 "Introductory Mathematics for Engineering Applications." Taught by *engineering* faculty, the course includes lecture, laboratory and recitation components, and is strongly supported by the literature on how students learn[1-5]. Using an application-oriented, hands-on approach, the course addresses only the salient math topics *actually used* in core engineering courses. These include the traditional physics, engineering mechanics, electric circuits and computer programming sequences. The EGR 101 course replaces traditional math prerequisite requirements for the above core courses, so that students can advance in the curriculum without first completing a traditional first-year calculus sequence. The Wright State model concludes with a more just-in-time structuring of the required math sequence, in concert with college and ABET requirements. The result has shifted the traditional emphasis on math prerequisite requirements to an emphasis on *engineering motivation for math*.

The Wright State model was first implemented in Fall of 2004, and its effect on student retention, motivation and success in engineering has since been widely reported[6-24]. The recent introduction of EGR 100/199 for initially underprepared students has further strengthened the approach, and has made the core engineering curriculum immediately accessible to roughly 80% of incoming engineering students at Wright State University.[8] For a typical incoming class of 300 students, is estimated that introduction of EGR 101 and EGR 100/199 has resulted in the retention of at least 30 additional sophomores per year in the Wright State engineering programs.

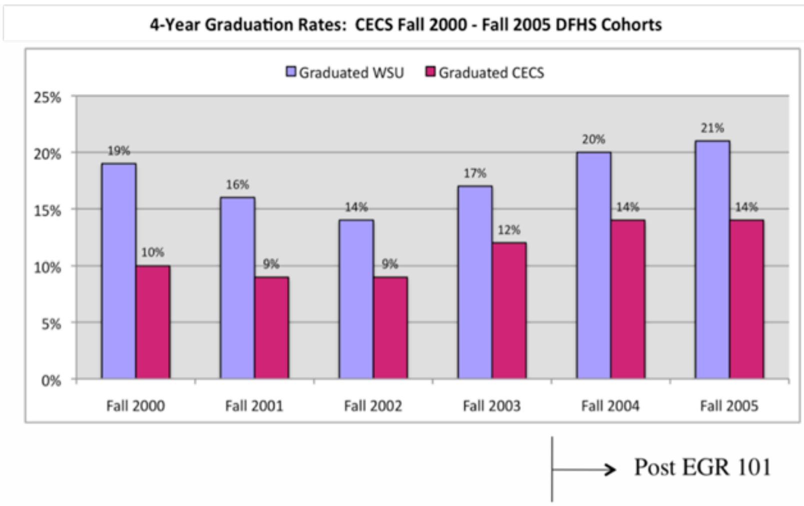

Figure 1. Impact of EGR 101 on College-Wide 4-Year Graduation Rates

In addition to first-year retention, the introduction of EGR 101 has already impacted college-wide 4-year graduation rates for the initial cohorts, which are roughly 4 percentage points higher than those of prior years (Fig. 1). For the incoming class of 2004, the impact of EGR 101 on 6-year graduation rates is overwhelming (Fig. 2). Of the students who took EGR 101, 71% completed a bachelor's degree from Wright State University, and 52% completed their degrees in an engineering or computer science (CECS) field. This compared to rates of 40% and 15% for students who did not take EGR 101. Based on tuition revenue associated with increased enrollment and graduation rates, the Wright State model is now fully sustainable.

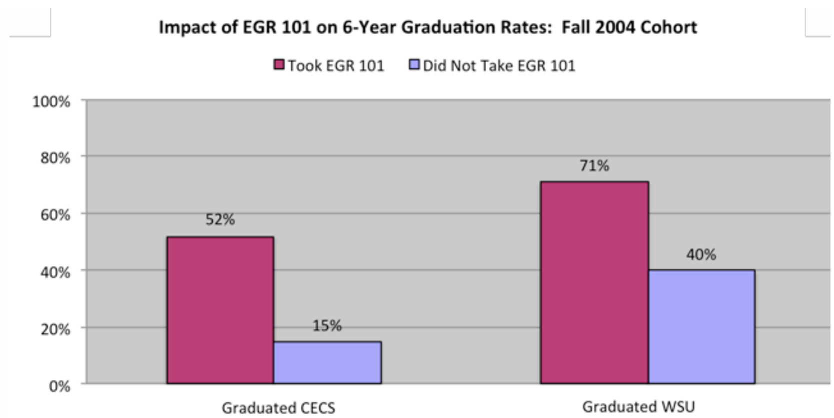

Figure 2. Impact of EGR 101 on 6-Year Graduation Rates

Highlights from a CCLI Phase 3 Initiative

A nationwide adoption and assessment of the Wright State model is now underway as part of a 2008 NSF CCLI Phase 3 award. The nationwide team includes 15 diverse institutions (primarily university but also at the high school and community college levels) representing strategic pockets of interest in some of our nation's most STEM critical regions. In addition to Ohio, these include Michigan, Texas, Oklahoma, California, Washington and Virginia. The dissemination component of the project has resulted in the addition of numerous unfunded collaborating instructions. All told, at least two dozen institutions have now piloted aspects of the Wright State model for adoption at their own institutions. This section includes highlights from a small subset of these institutions, each of which has implemented a novel adaptation of the Wright State model.

University of Tulsa:

Background: The University of Tulsa (TU) is a private, highly selective university offering bachelors and doctoral degrees in the full range of academic disciplines. The college of engineering and natural sciences houses 10 departments including 5 engineering departments (Mechanical, Chemical, Electrical, Petroleum, and Engineering Physics), Chemistry, Biology, Geosciences, Computer Science, and Mathematics. Total graduate enrollment in the college is approximately 1,000 students and the total university enrollment is approximately 3,100.

Recent class credentials at TU have been very good, with an average freshman entering with a composite ACT of 29 or a composite SAT of 1270. TU does not have separate entrance requirements for engineering or any other major, and an accepted student self-declares their intended degree. There are no formal math placement exams at TU and either the student's advisor or the student decide whether a remedial math is necessary. This last year a remedial math path was implemented in the Calculus I sequence. If student performance was subpar on the first exam then they were shunted into a pre-calculus program. Overall, TU students are not limited in pursuing engineering majors because of their math preparation.

TU's goals for participation in the Wright State math program were threefold:

1. Improve the retention of the students in Mechanical Engineering.
2. Assess the attitudes of first and second semester freshman with regards to math and engineering.
3. Understand the driving factors for students leaving engineering at TU.

Implementation of the math program was somewhat different from the model as utilized in Wright State as we describe below, and was limited to the Mechanical Engineering department at TU. Enrollment in the Mechanical Engineering department is typically about 40 students per class and the total current enrollment is approximately 150 students. The department consists of 8 full-time faculty members. Students participating in the course had an average composite ACT of 30 with a standard deviation of 4. Retention, based on tracking students who enrolled in the ME introduction course has historically been 52%, this number does not include any student who transfers into mechanical engineering from other majors. When these students are included the rate is 62%.

Implementation: The course was implemented within the framework of a two-credit hour introductory computer applications course. Originally, this course was intended to introduce incoming freshmen to the basics of computer and computer applications use within the context of Mechanical Engineering. A course notebook and lab-set based on the WSU course handbook was created to fit the format of the class. This format consisted of a 75 minute lecture period and a weekly three-hour, computer-based laboratory period. The two main objectives of this course were to introduce the use of excel and VBA (visual basic) to students within the framework of the WSU math model. Only 4 of the 11 labs were devoted exclusively to topics other than engineering-related mathematics. These lab periods were necessary to introduce engineering-related features in Microsoft Word, such as the equation editor and the insertion and manipulation of graphs, and to cover technical programming topics in VBA necessary to complete the rest of the course. We were unable to implement the course such that successful completion would count as the required perquisite for Physics I.

Again, since we believed that retention in Mechanical Engineering at TU is generally not aptitude-based, we felt that implementing the applications-based math model would allow us to determine the extent that attitudes-based withdrawal was impacting our retention.

Preliminary Results and Discussion: In addition to raw retention statistics, our primary assessment tool was a 45-question Likert-type survey designed to assess student perceptions, attitudes, and academic background. This survey was constructed and implemented with the assistance of a faculty member in the Industrial and Organizational Psychology department. The survey was administered in the last class period to capture the students' attitudes after they had completed the semester-long course.

The survey was designed to measure both broad attitudes about Mechanical Engineering and math as well as specific opinions about the course itself. The items were empirically and rationally divided in 5 scales emphasizing key areas of interest, specifically, 1) desire to know why something was being taught, 2) willingness to get help outside of class, 3) math confidence 4) withdrawal attitudes, and 5) liking the course. The students were also given the opportunity to follow up with open-ended answers to some of the questions.

We have collected 98 surveys with an overall 83% response rate from five semesters of the course given from spring of 2009 to spring of 2011. Results from two of the areas, mathematics and withdrawal, are presented in Tables UT-1 and UT-2.

Table UT-1: Math Confidence

Item	Mean	SD
1. I like math.	4.15	0.85
2. I can use math to solve problems.	4.35	0.72
3. I like physics and other science classes.	4.17	0.75
4. I find it easy to apply what I learn to my interests and activities	3.95	0.84
Total Score	4.16	0.55

Table UT-2: Withdrawal Attitudes.

Item	Mean	SD
1. I am thinking about changing majors	2.12	1.07
2. I have looked into the requirements for other majors	2.87	1.25
3. I am thinking about leaving the University of Tulsa before graduating	1.63	0.88
4. I am considering going to graduate school in engineering or a related discipline.	3.42	0.98
5. I am glad that I chose Engineering as a major.	4.16	0.83
6. I withdraw from or drop classes when they are too	2.23	0.95

difficult or inconvenient		
7. I considered majors other than engineering	3.53	1.18
8. I am thinking about attending law school or medical school.	1.80	1.10
Total Score	2.33	0.61

The mathematics attitudes of our students are on the high end of the scale indicating that our students are already positively predisposed to mathematics. The withdrawal attitudes indicate that, after completing the course, most students were planning on staying in engineering. Our students also indicated that they had considered other majors besides engineering, though we do not know if that means other STEM field or non-STEM fields. However, these attitudes were more varied and less extreme than the math attitudes, and a number of students were considering other options. These attitudes can be seen in comments such as *I do not like the courses required for ME and I did not do well in calc; I really don't enjoy engineering. Also, I want to be a lawyer and am afraid I am becoming illiterate;* and *I still haven't had any real Mech E courses. May still change majors if they don't work out.*

To examine which variables were most predictive of these withdrawal attitudes, correlations between the survey responses and the withdrawal score were calculated; these are summarized in Table UT-3.

Table UT-3: Correlations with the Withdrawal Attitudes

Variable	Pearson's *r*
Gender	**.29**
ACT	-.20
GPA	**-.26**
Course Grade	**-.37**
Desire to know why something was being taught	**.22**
Willingness to get help outside of class	-.11
Math Confidence	-.14
Liking the Course	**-.24**

Note: Bold indicates statistical significance ($p < 0.05$). For Gender 1 = male and 2=female.

These correlations indicate that there are several significant predictors of withdrawal attitudes. Negative values indicate that the particular variable is correlated with the student *not* intending to withdrawal, these are GPA and Course Grade. Additionally, students that liked the course and wanted to know why something was being taught also had a significantly higher indication of the intention of staying in engineering. Similar to findings across the STEM fields, female students were more likely to think about withdrawing from engineering at TU.

To date, we have confirmed 2 students who have withdrawn from mechanical engineering within the survey cohorts. Both of these students switched majors, one to chemical engineering and one to math and pre-law. We will have our first set of graduating seniors from the initial, 2009, survey cohort graduating next school year and we will be able to calculate our retention rate for comparison with the historical rate. However, to date the retention rates appear to be quite good compared to the year prior to the implementation of the course and survey as shown in Table

UT-4. These results indicate that the class may be having a significant impact on overall retention rates in Mechanical Engineering. The large withdrawal rate in 2008 represents a rather large number of major changes out of STEM when compared to the following years.

Table UT-4: Retention Rate Through Fall 2011

Enrolment Year	Freshman Enrollment	Withdrawal	Retention Rate
2008	45	22	51 %
2009	41	12	71 %
2010	53	16	70 %

Based on the current results we are optimistic and excited about this program. It has given us the opportunity to understand more of why our students choose to complete their degrees in engineering which opens the doors for interventions and changes targeted at venerable populations. Specifically, it seems like this class might help to introduce the students to more practical Mechanical Engineering applications early in their academic careers and give them the confidence to complete their math and physics sequences. We are approaching the first of our 4-year retention rates and are expecting to be able to transition to a full curriculum-based implementation of the program based on these results.

Oklahoma State University:

Background: Oklahoma State has been offering a design centered version of the course during each fall semester since 2008 (so 2011 marks the fourth implementation). For the OSU implementation of the Wright State Model (WSM), OSU has integrated design in a problem-based learning format due to the instructors' (Dr. Karen High and Dr. Alan Cheville) experience with this pedagogy, as well as to meet local, ABET-dictated constraints on the courses that were be replaced.

The design cycle that has been implemented in this course (developed by Dr. Alan Cheville) is as shown in Fig. OSU-1.

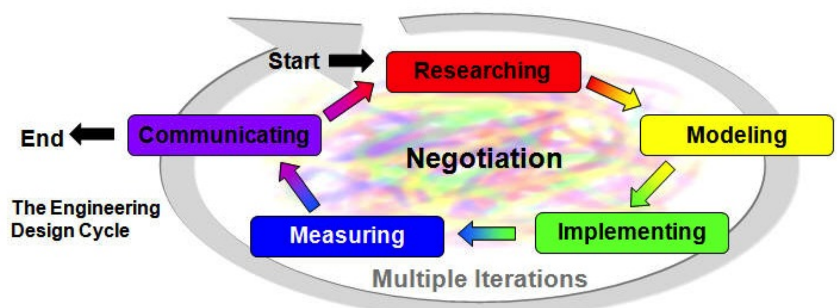

Figure OSU-1. Oklahoma State University Design Cycle

The engineering design cycle shown above illustrates how engineers approach a design problem. In the OSU course, students follow the complete design cycle for each of the labs.

Implementation: This course introduces students to the methods by which math topics are used in engineering science and design courses. Students apply mathematics through experimentation and design projects. Both analytical and computational (MATLAB) techniques are used for data analysis and graphical representation. The course objectives are listed below. At the conclusion of the course the students should be able to:

a) Use algebra, systems of equations, trigonometry, sinusoids, derivatives, and integrals in solving engineering analysis and design problems
b) Work effectively in teams
c) Communicate engineering work effectively in written form
d) Use Microsoft word PowerPoint and MATLAB to present technical data
e) Use MATLAB to solve equations, represent data, and as a tool for engineering design
f) Acquire, plot and analyze data from an experiment
g) Recreate and explain the engineering design process

The general structure of the course is shown in Fig. OSU-2. The course consists of three modules—algebra (context of circuits and chemical mixing), sinusoids (context of Snell's Law and a clock reaction), and calculus (context of a calculus based car)—which each focus on a general mathematical topic critical for engineering. Several weeks at the beginning and end of course are reserved for introduction and wrap-up. Each module covers two topics on math that engineers use every day. Each topic will be covered over two weeks and each topic has an engineering analysis project and an engineering design project. How each topic starts, beginning on Tuesdays, and is taught over two weeks is shown on the right-hand side of the figure.

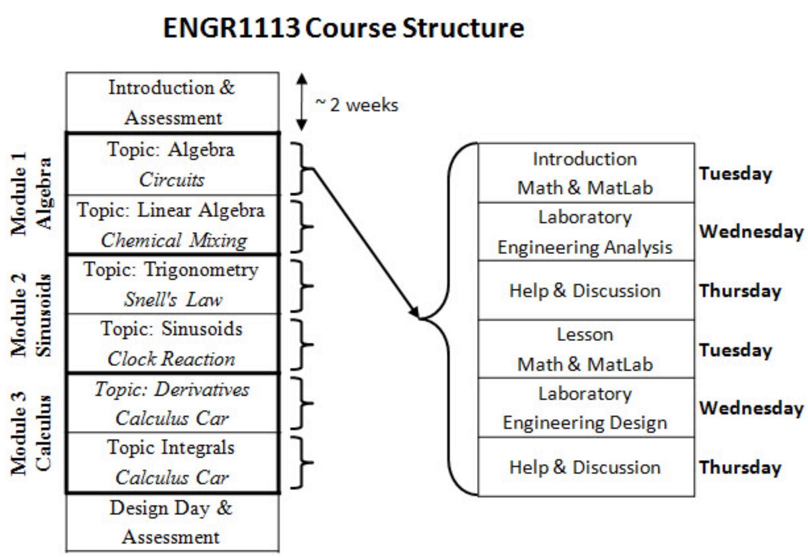

Figure OSU-2. ENGR 1113 Course Structure

At the conclusion of a four week module (this is for the three major topics, Algebra, Trigonometry, and Calculus) each team submitted a report and each individual student completed a reflection paper. Topics included in the team reports and reflections will include: the student's contribution to lab, summary of data, and what the student learned in the lab. The team reports took a variety of forms from written to oral to poster. The individual reflections had the students answer each of the following three questions:

1. How do your current interests, knowledge, and skills fit with becoming an engineer? (beginning of the semester)
2. What are the similarities and differences between your past design experiences and what you are learning about engineering design in this class? (middle of the semester)
3. How and why has your understanding of engineers' use of math changed this semester? (end of the semester)

For the individual reflections, students worked with writing fellows to develop final drafts of their papers. Writing fellows are upper class engineering students that are trained in effective peer mentoring. The students turned in their first drafts to the writing fellows and the documents were reviewed for style, grammar, organization and adherence to the specifications of the assignments. The writing fellows provided written feedback and met with the students face-to-face to go over the papers. The students incorporated the feedback into their final draft submitted to the course instructors.

Preliminary Results and Discussion: The following lists information about the four years the course has been offered

- 2008 cohort
    - Students mostly weak in math skills
    - Karen High coordinator with Ph.D. Student as main instructor
    - MATLAB main computational tool
    - 35 students (8 females or 23%) in 2 sections
- 2009 cohort
    - Students with weak, medium and high math skills
    - Most positive attitude of the four cohorts
    - Karen High coordinator with Ph.D. Student as main instructor
    - MATLAB main computational tool
    - 43 students (10 females or 23%) in 2 sections
- 2010 cohort
    - Students with weak, medium and high math skills
    - Karen High coordinator with Ph.D. Student as main instructor
    - MATLAB main computational tool
    - PhD Student left project at the end of year
    - 48 students (9 females or 19%) in 2 sections
- 2011
    - New instructor Fall 2011
    - EXCEL main computational tool
    - Students did a semester long design project in addition to weekly labs
    - Students reported to be weak in math skills
    - 23 students (5 female or 22%) in 1 section

The main indicator of success for the students was their performance on a math content test. The values reported are percentage of questions answered correctly. This content test had 27 items and was developed and administered to the student in 2009 to 2011 (results from 2100 are not available). As can be seen in Table OSU-1, the ENGR 1113 Engineering math students improved in their content knowledge from 43% to 52% in 2009, and in 2010 from 54% to 66%.

The 1111 group is a comparison group of first semester freshman students that were chemical engineering students and very academically prepared. The 2033 students are second semester. sophomores in chemical engineering that have been through the three calculus course sequence. The most positive item to note is that in 2010, the 1113 student's math content knowledge increased to a point (66%) to be roughly equal to second semester sophomore chemical engineering students (67%). Neither of the comparison freshman groups made those gains.

Table OSU-1: Performance on Math Pre/Post test

Year	Cohort	N	Pre %	Post %
2009	**1113**	39	43.0	51.6
	1111	*16*	*62.8*	*63.6*
2010	**1113**	45	53.7	66.2
	1111	*38*	*51.0*	*59.2*
	2033	40	67.2	68.0

Table OSU-2 shows the confidence the students had in their answers. The two cohorts reported are the ENGR 1113 cohort and the comparison ENGR 1111 cohort of first semester freshman. The confidence scale was added to the math assessment in 2010. As is show in Table OSU-2, the student confidence increase for the ENGR 1113 cohort was greater (0.7) than the comparison group of first semester freshman (0.4).

Table OSU-2: Math Confidence

		N	Pre	Post	Diff
2010	**1113**	45	53.7	66.2	12.6%
			3.2*	3.9*	0.7
	1111	38	51.0	59.2	8.2%
			3.1*	3.5	0.4

*Confidence scores are 1 to 5 with 5 being most confident on a Likert Scale

University of Maryland:

Background: In 2010, the University of Maryland in College Park, MD began offering Introductory Mathematics for Engineering Applications (IMEA) as an *early college* course through local high school partners. In the fall semester of 2010, the course was offered at the Collegiate Academy, a high school within the Friendship Public Charter School System in Washington D.C. Then, in the fall semester of 2011, the course was offered at Oxon Hill High School within the Prince George's County Public School System in Maryland. Based on the initial success of the early-college offering, the university plans to offer the course in 2012 at Friendship, at Oxon Hill, and also at Wheaton High School in the Montgomery County Public School System in Maryland.

As described above, the initial development of the IMEA course at WSU was motivated by the need to increase retention of engineering students, in particular those students who struggle with the Calculus courses encountered near the beginning of the engineering curriculum. At the University of Maryland, this philosophy was extended to high school students who are potential applicants to engineering programs. It is hypothesized that a number of good candidates for engineering programs may choose not to apply to or enroll in engineering programs because of a lack of mathematics self-efficacy and engineering career awareness. Additionally, it is believed that there is an additional cohort of students who choose to enroll in engineering programs but quickly leave because of discouragement in the mathematics encountered in the program.

In order to increase the number of students who choose to apply to and enroll in engineering programs, and to ensure continual matriculation of these students within engineering, we have initiated an early college offering of the IMEA course for high school students who are good candidates for engineering programs but who may be at risk of attrition in the program. We hypothesize that high school students who participate in a college-level offering of the IMEA course will acquire increased mathematics and engineering self-efficacy. According to Social Cognitive Career Theory (SCCT), this can lead to success at the university level because the acquired self-efficacy enables the students to remain encouraged about their scientific potential, even during the rigorous course work that sometimes prevents students from matriculating through degree programs[25-27].

Implementation: The early college IMEA course at the University of Maryland is offered for college credit within the A. James Clark School of Engineering. The course is offered at the same rigor as initially intended when developed at WSU. The course is delivered by the Fischell Department of Bioengineering, and is administratively supported by the University of Maryland Outreach. While the early college offering of the IMEA course is for college credit, the current deployment of the course has been taught within the classrooms of the high school partners for practical reasons.

In order to enroll in the course, students must first apply to the University of Maryland. A committee is assembled each year to evaluate applications and provide decisions on admissions. In general, a 3.0 grade point average is required. In addition, students are required to have completed mathematics courses through trigonometry (pre-calculus is preferred as a pre-requisite or co-requisite). Upon gaining admission, students are enrolled by the Outreach office and are registered for the course. Because the course is offered through the University of Maryland, the students receive a grade for the course from the university, and thus will have a transcript record.

Instruction for the course is provided by an adjunct faculty member of the Bioengineering Department. For the 2010-2011 offerings, the instructor was Prof. Jennifer Wolk, who received a Ph.D. in Materials Science and Engineering at the University of Maryland in 2010. Utilizing an instructor with an advanced degree in engineering helps to ensure that the intended college-level rigor and style of the course is maintained. Support is provided to the instructor in the classroom by a high school math or physics teacher at the partnering high school. The instructor delivers the lectures to the students, while the high school teacher leads recitation session, facilitates the laboratory sessions, and provides Matlab instruction. Each week consists of two 75-minute lectures delivered by the instructor, one recitation session, and one lab session. Lectures and labs are directly adapted from the curriculum distributed by WSU.

The support provided by the high school teacher in the classroom is critical to the success of the early college IMEA course. To ensure adequate preparation, we invite the high school teachers to participate in a 6-week workshop on the University of Maryland campus during the summer before the course is offered. In 2010 and 2011, the workshop was supported by the NSF Research Experiences for Teachers program. The teachers are tasked with adapting and customizing the laboratory and Matlab exercises for their classrooms. This enables the teachers to become familiar with the course, the labs, and Matlab. It also facilitates communication between the Bioengineering Department faculty, the instructor, and the high school teacher.

Figure UM-1. Pre-College Students Collaborate on IMEA Aerospace Design Project

In addition to the curriculum that has been made available by WSU, the University of Maryland has added a design project into the early college offering of the IMEA. Because of this additional requirement, the IMEA course is offered as a 4-credit course. Students are given the choice of participating in an aerospace project, a bioengineering project, or a hydrodynamics engineering project. In addition to her appointment at University of Maryland, Prof. Wolk is an engineer for Naval Surface Warfare Center, Carderock Division (NSWCCD). The partnership between University of Maryland and NSWCCD allowed for project mentorship by volunteers from NSWCCD, Lockheed Martin, and by the instructor. Within the scope of the project, students must use mathematical fundamentals to conduct an engineering design. Examples include calculations for carrying capacity and airfoil selection based on experimentally measured principles of aerodynamics, such as kinematic equations of motion, lift, drag, and thrust (Figure UM-1).

The inclusion of the design project is motivated by the potential to increase the mathematical and engineering self-efficacy that students receive from the course. It is believed that employing the mathematical fundamentals acquired in the course to solve real-world engineering problems will have a lasting effect on the students' perceptions of (i) the value of mathematics, and (ii) their ability to apply mathematics to solve problems. Furthermore, the students' awareness of engineering careers is increased by working on engineering problems with engineering professionals. As stated above, SCCT suggests that these experiences can increase success in achievement at future levels of an engineering career path[25-27].

Preliminary Results and Discussion: The pilot course at Friendship Collegiate Academy was comprised of 13 African American students; eleven students were seniors and two students were juniors. Eleven students completed the course at Friendship with three students receiving As, seven students receiving B's, and one student receiving a C. All seniors from the pilot course went onto higher education. The top student in the course is currently enrolled at Columbia University, pursing a degree in Computer Science. This student also spent the summer as an intern at the Naval Surface Warfare Center under the Science and Engineering Apprenticeship Program. Within this course, another student received a Gates Foundation Scholarship to pursue a pharmaceutical degree. The 2011 course offering at Oxon Hill High School comprised of 17 students, the majority of whom were African American. Many of the students showed a pre-disposition towards science and engineering prior to the course.

The IMEA course offers students an opportunity to apply traditional mathematics to engineering applications. Beyond the lecture and lab experiments, students are able to begin the transition from high school to college with the rigor required within the course. Students have noted that the early college experience will greatly benefit them as they move onto college. The hands on nature of the labs and design projects have also exposed the students to opportunities within engineering that would have been otherwise difficult to experience. The following quotes were provided by the students regarding the course:

"As a prospective Architectural Engineer, I have been both challenged and encouraged. I am more prepared for the rigor of an undergrad engineering program, and I am confident that I will succeed as an engineer."

"This course has offered me a great challenge and allowed me to see math in a new light. I am confident that I will be at least somewhat prepared for entry level engineering courses."

"This class has challenged me and has taught me how to study more efficiently."

Further illustrating the advanced and challenging nature of the course, the high school instructor at Oxon Hill High School said that "It's a great opportunity for the students. In my experience, some of the hands-on opportunities they are getting, I didn't explore until graduate school."

In the near future, quantitative results will be available for distribution. At the beginning of the course, students took two surveys: one on engineering career awareness and one on self-efficacy in mathematics. The students will soon take the surveys again, as they have recently completed the course. We hypothesize that the IMEA course will result in a dramatic increase in both engineering career awareness and self-efficacy in mathematics. In addition, students took the University of Maryland's mathematics entrance exam (an old version). They will re-take this same exam in the near future. Based on the strong improvement in mathematical fundamental achieved through the course, we expect to record a significant improvement in the exam scores.

Summary

The Wright State model for engineering mathematics education seeks to increase student retention, motivation and success in engineering by removing the first-year bottleneck associated with the traditional freshman calculus sequence. The approach includes the development of a novel freshman engineering mathematics course EGR 101, along with a substantial restructuring of the early engineering curriculum. This has been further strengthened by the introduction EGR 100/199 as a precursor to EGR 101 for initially underprepared students. The Wright State model is designed to be readily adopted by any university employing a traditional engineering curriculum, and proposes an immediate solution to math-related attrition in engineering. The approach has already had a dramatic impact on student retention, motivation and success in engineering at Wright State University, and is now being piloted by at least two dozen institutions across the country. This paper has included highlights from three of these institutions, whose novel implementations seem to support the widespread transferability of the approach. In particular, each of these institutions have provided innovative adaptations of Wright State's engineering math materials to suit its own enrollment, demographics and curricular objectives. Regardless of the setting, preliminary results suggest that integrating mathematics with engineering applications can have a dramatically positive impact on student retention, motivation and success in engineering.

Acknowledgments

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Program Information

More information on the Wright State model for engineering mathematics education (including all course materials for EGR 101) can be found at http://www.cecs.wright.edu/cecs/engmath/. Textbook information[28] is available at http://www.wiley.com/college/rattan.

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