Using More Frequent and Formative Assessment When Replicating the Wright State Model for Engineering Mathematics Education

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Abstract

This "Complete Paper – Evidence Based Practice" describes how a mid-sized private university in the Southeast has created an experimental first-year engineering course based on the Wright State Model for Engineering Mathematics Education. The course aims to increase student retention, motivation and success in engineering through an application-oriented, hands-on introduction to engineering mathematics. When compared to the traditional Wright State Model for Engineering Mathematics Education, the new course also focused on student communication (written, oral), teamwork, self-regulated learning and professionalism. The new experimental course also uses more frequent and formative assessment techniques. Faculty used Wright State's sample homework assignments to provide students with formative feedback and Wright State's sample exams to provide summative feedback. However, the format of the experimental course had faculty use more frequent and formative assessments to better understand what and how students learn the course content. Preliminary qualitative data was collected from students via one-minute papers, mid-term evaluations, exam wrappers, and final course evaluations. Preliminary quantitative data was gathered from student course grades and cumulative GPAs (CGPAs). Thus far, students taking the experimental first-year engineering course believe they gain confidence and skills such as problem-solving, time management, study habits, computer programming, as well as real-world applications of math and physics. Thus far, over 80% of students have earned a grade of C or better in the experimental first-year engineering course along with their pre-calculus or calculus class. More than 80% of students have also maintained a CGPA above a 2.0. This study is part of larger overall assessment of an experimental first-year engineering course based on the Wright State Model for Engineering Mathematics Education at a mid-sized private university in the Southeast. Preliminary quantitative and qualitative data have been collected from the experimental course, but this paper will focus on qualitative data that has come from formative assessment techniques.

Introduction

Historically, many first-year engineering students have encountered bottlenecks or obstacles when seeking to complete their degrees (Klingbeil, Rattan, Raymer, Reynolds, and Mercer, 2007; Ohland, Yuhasz, and Sill, 2004). Academic bottlenecks can consist of required first and second year mathematics courses with high failure rates such as Calculus I. Some college faculty, staff and students label required math, science and engineering courses with high failure rates as "weed out classes." Unfortunately, if students are unable to successfully pass their introductory engineering, science and math classes then they will not have the pre-requisites they need for second and third-year engineering courses. For instance, many engineering degree programs expect students to pass a series of physics and calculus courses before being eligible

for engineering courses including circuits, solid mechanics, thermodynamics, statics and dynamics, etc.

One course that many first-year engineering students are expected to take and pass is Calculus I. Many first-year engineering students need to enroll in Calculus I during their very first semester in order to complete their bachelor's degree within four years. So, first-year engineering students are expected to already have college credit for courses like Calculus I or they need to achieve minimum scores on university-administered placement exams to immediately begin Calculus I. If first-year engineering students do not achieve minimum placement exam scores, they are typically placed in remedial math courses that do not count towards their degree. Remedial courses can increase student costs and time to degree.

The Wright State Model for Engineering Mathematics Education helps first-year engineering students overcome traditional bottlenecks caused by required courses such as calculus and physics. The Wright State Model allows first-year engineering students to meet necessary math prerequisite requirements through immediate exposure to math topics from sophomore and junior-level engineering courses (Klingbeil, Mercer, Rattan, Raymer, and Reynolds, 2004). It differs from traditional undergraduate mathematics courses in several ways. One, the Wright State Model includes recitation, lecture, and laboratory components. Two, engineering faculty teach first-year engineering students the recitation, lecture and laboratory components instead of math faculty. Lastly, the Wright State Model presents all math concepts within an engineering context while solely using math topics and examples from core engineering classes. After being exposed to the Wright State Model for Engineering Mathematics Education, engineering students have had increased graduate rates and GPAs, with the greatest impact on underrepresented groups (Klingbeil and Bourne, 2013).

Faculty sought to increase first-year engineering students' retention, motivation, and success by creating an experimental course based on the Wright State Model for Engineering Mathematics Education at a mid-sized private university in the Southeast. To be eligible for the experimental course, students had to receive a math placement score at or above the pre-calculus level. By successfully completing the experimental course, students received an alternative pre-requisite for a sophomore-level statics course. To be eligible for the statics course, students have historically had to complete an engineering graphics course and their first physics course while also being enrolled in their final calculus course.

This paper describes the experimental first-year engineering course. Faculty used Wright State's sample homework assignments to provide students' with formative feedback and Wright State's sample exams to provide summative feedback. However, the format of the new EGR_Math course had faculty use more frequent and formative assessments to better understand what and how students learn the course content. In the following sections of this paper, the more frequent and formative assessment techniques are detailed.

Literature Review

Many faculty members contribute to the scholarship of teaching and learning by using evidence-based teaching approaches to evaluate and improve both their teaching as well as their students' learning (Boyer, 1990; Society for Teaching and Learning in Higher Education, 2019; Karen L. Smith Faculty Center for Teaching and Learning, 2019). Summative assessment is a way to assign grades through exams and other graded assignments (Elberly Center, 2019b). On the other hand, formative assessment is typically a way to determine student's current level of understanding without punitive grades. Formative assessment can help with meta-cognition and it can also help to promote student achievement (Angelo and Cross, 1993; Hattie, 2009).

Purpose

The purpose of this study was to use more frequent and formative assessment in an experimental first-year engineering course based on the Wright State Model for Engineering Mathematics Education. The course aims to increase student retention, motivation and success in engineering through an application-oriented, hands-on introduction to engineering mathematics. When compared to the traditional Wright State Model for Engineering Mathematics Education, the new experimental course uses more frequent and formative assessment techniques.

Method

This study is part of larger overall assessment of an experimental first-year engineering course based on the Wright State Model for Engineering Mathematics Education at a mid-sized private university in the Southeast. Preliminary quantitative and qualitative data have been collected from the experimental course but this paper will focus on qualitative data that has come from formative assessment techniques.

Participants. Students who were currently taking the experimental first-year engineering course, referred to as EGR_Math in this paper, were eligible to participate in the study. Also, to be eligible for the experimental course, students had to receive a math placement score at or above pre-calculus level. All participants shared several important characteristics. First, only undergraduates were taking the course and asked to participate to eliminate any unforeseen variability in experiences between undergraduate and graduate students. Second, all participants had declared a major in engineering or a subfield (for example, mechanical), as defined by the National Science Foundation (NSF).

Since the EGR_Math course was not a requirement for engineering students' degree programs, academic advisors helped engineering faculty identify and recruit students for the course. Students were recruited using a variety of strategies including paper or electronic announcements and college listservs. Eligible students were contacted via telephone or email by academic advisors to enroll them in the experimental course. Through this recruitment approach, in the fall

of 2017, a total of 28 first-degree-seeking, first-year engineering students completed the EGR_Math course.

The university's first-year engineering department offered two sections of the EGR_Math course. The same faculty member taught both sections of the course while two different undergraduate teaching assistants (TAs) helped with each course section. At the university, the 28 students represented about five percent of all first-degree-seeking, first-year engineering students. Of the 28 students who completed the EGR_Math course, approximately 4% had an international country of origin and 36% were women. In addition, roughly 67% were White, 11% were Hispanic, 11% were Black and 7% were of an unknown race/ethnicity. As of Fall 2017, undergraduate students from the Southeastern campus were 13% international students and 22% female. Moreover, 56% were White, 7% Hispanic, 7% were multi-racial, 5% Asian, and 5% Black. See below for Figures 1-2.
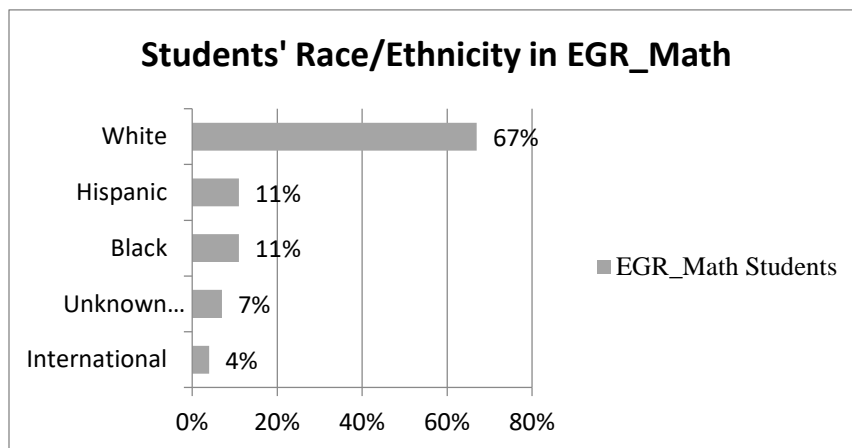
Figure 1: Race/Ethnicity of EGR_Math Students
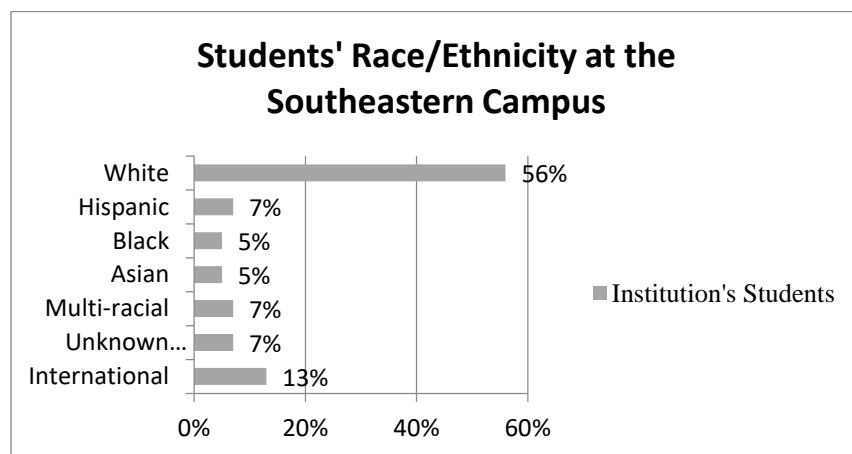
Figure 2: Race/Ethnicity of the Institution's Students

Data Collection and Analysis. The primary method for data collection consisted of open-ended survey items via the EGR_Math course management system. Survey items were developed in the form of one-minute papers, exam wrappers and midterm feedback (Angelo & Cross, 1993; Eberly Center, 2019a). Students were encouraged to complete electronic one-minute papers during the final few minutes of each class and lab to help instructors plan for the following class or lab session. One-minute papers included, but were not limited to, open-ended questions about students' perceptions of *the most important point of the class* along with *what question remained unanswered* in students' mind (Angelo & Cross, 1993).

In addition to one-minute papers, exam wrappers allowed students to think about what study techniques did and did not work well. Following exams, students responded to questions like, *what activities did you do to prepare for the exam?* Lastly, the university's teaching and learning center collected midterm feedback by asking students open-ended questions such as, *what about this course and/or the instructor's teaching of it most helps your learning?* Students were also asked midway through the semester, *what suggestions can you offer that would help make this course a better learning experience for you?*

As an incentive, student participants earned extra-credit points for their completion of each one-minute paper and exam wrapper. Each survey took students about five minutes or less to complete. Many students provided answers to the items via the course management system before leaving class. A representative from the university's teaching and learning center collected midterm feedback from students via additional open-ended survey items.

Student TAs downloaded electronic one-minute paper data from the course management system. They then compiled and saved the data in Microsoft Excel before sharing data with instructors via Google docs. Data was organized into different Excel columns based on each of the four questions students could potentially complete for the one-minute paper. Based on the questions, the headers for the different Excel columns were for the (a) *most important point of the class*, (b) *most surprising idea or concept*, (c) *questions that remain unanswered*, and (d) *least clear/most difficult to understand*. Instructors used data to determine which topics needed to be reiterated at the beginning of each class and during exam review sessions.

Student TAs also downloaded exam wrapper data and organized it in a similar way. They also added color codes to exam wrapper data to visually group similar topics together. Finally, representatives from the institution's teaching and learning center compiled midterm feedback in Microsoft Word and then summarized the data based on consistent topics or trends. The teaching and learning representative also met with the course instructor to offer additional suggestions and answer any questions.

Findings

During the fall of 2017, preliminary open-ended survey data was collected from first-engineering students via one-minute papers, exam wrappers and midterm feedback. After each class and lab session, many students identified the most important topic of the day and students tried to relate course topics to the real world. Whenever students did not correctly identify the most important topic, the instructor would reiterate it again at the start of the following class session. At times, the instructor would use class demos and YouTube videos to help students better understand important topics. Below, Table 1 shows all of the topics that faculty covered in the course.

Table 1: Schedule of Course Topics

Schedule	Topic
Week 1	Application of Algebra in Engineering – Linear and Quadratic Equations
Week 2	Trigonometry in Engineering – One and Two-Link Planar Robots
Week 3-4	2-D Vectors in Engineering
Week 5	Complex Numbers in Engineering
Week 6	Sinusoids and Harmonic Signals in Engineering
Week 7	Systems of Equations and Matrices in Engineering
Week 8-9	Derivatives in Engineering (Dynamics, Electric Circuits, Strength of Materials)
Week 10-12	Integrals in Engineering (Statics, Dynamics, Electric Circuits)
Week 13-14	Differential Equations in Engineering (First and Second-Order)

Based on one-minute paper data involving the *most surprising idea or concept, questions that remain unanswered*, and topics that were *least clear/most difficult to understand*, one of the student TAs created a frequently asked questions (FAQs) document and a topic flowchart to aid in student learning of course concepts. When creating the FAQs document and the topic flowchart, the instructor encouraged the student TA to use simple terminology that first-year engineering students could easily understand. Below, Figures 3-5 contain (a) sample student responses to a one-minute paper, (b) sample questions from the FAQs document and a (c) sample version of the topic flowchart.

week 5 (Tues)	Most important point of the class?	Most surprising idea or concept?	What question remains unanswered in	least clear/most difficult to understand topic?
1	switch between polar, rectangular, and exponential forms			
2	Substituting formulas given and changing forms			
3	be able to switch between each form.			
4	How complex numbers applies to engineering.			
5	apply different forms in engineering			
6	circuitry equations			
7				
8	convert between the different forms of writing complex numbers			
9	be able to switch between each form.			
10	change forms			
11	Different forms and converting between all of them.			
12	understanding of the use of complex numbers			
13	Converting answers between forms.			
14				
15	Going over polar form, exponential form , and rectangular form.	reviewed everything from yesterday	Nothing everything was answered	Some of the formulas and remembering all of them
16				
17			Why is there 4 different forms to write the answer in?	
18	It is important to know how to convert			
19	being able to go from one formula to another backward is REALLY HELPFUL!			
20		how much imaginary numbers are used in circuitry.		
21	how to use complex numbers in circuitry.			
22	Complex numbers			forms of answers, conversion of forms
23				
24	convert an answer with an imaginary number			
25	convert to polar form to make some problems easier			
26	change to and from polar, exponential, and rectangular form			

Figure 3: Sample Student Responses to a One-Minute Paper (Topic: Complex Numbers)

Figure 3 shows students' responses after being introduced to polar and rectangular form, as well as complex numbers. From this table, one can see that the students were interested in how the forms related to each other, and that they had trouble with confusing all the various forms. As previously mentioned, students were encouraged to answer at least one question within electronic one-minute papers during the final few minutes of each class and lab to help instructors plan for the following class or lab session. One-minute papers included, but were not limited to, open-ended questions about students' perceptions of *the most important point of the class* along with *what question remained unanswered* in students' mind (Angelo & Cross, 1993).

FREQUENTLY ASKED QUESTIONS

→ What is the difference between polar and rectangular form?
  ◆ Polar: Gives you the angle and the magnitude
    • Use trig to find components
  ◆ Rectangular: gives you each component
    • Use pythagorean theorem to get magnitude, trig to find angle

→ Which way is best for solving systems of equations?
  ◆ Matrix method: when you have three or more equations and can use Matlab, otherwise this method can be time consuming
  ◆ Substitution: For two or three equations, or when variables in the equations easily cancel out
  ◆ Graphing: not very accurate, use when you have a bunch of easily graphable equations (lines, parabolas, etc)

→ When do we use certain rules and why?
  ◆ Power rule: When you have a variable raised to a number (ex: $5x^2$)
  ◆ Product rule: When you have two functions multiplied by each other (2 expressions with variables in them) (ex: ($5x^2y^3$))
  ◆ Quotient rule: When you have two functions divided by each other (2 expressions with variables in them) (ex: $5x^2/y^3$)
  ◆ Exponential rule: When you have e raised to some variable (ex: e^{3x})
  ◆ Chain rule: When you have a function inside another function (ex: $sin(5x^2)$)

→ What exactly is a derivative?
  ◆ The rate of change of a function (how a function changes with respect to some variable, such as volume with respect to time is dV/dt)
  ◆ If you graph the function, it is the equation of the slope of the line (the equation of the line tangent to your graph at some point)
    • It's only equal to the slope if your equation is linear! Otherwise you have to plug in a point to find the slope because it's not the same everywhere on the graph

→ What is an integral?

Figure 4: Sample Frequently Asked Questions (FAQs)

Based on student responses from Figure 3, one of the student TAs created Figure 4, which is a frequently asked questions (FAQs) document. Sample student responses on complex numbers from Figure 3 led to the first question and set of answers in Figure 4. Therefore, the instructor not only used Figure 4 to address student misconceptions in class but also to document ideas for future use. The student TA worked with the instructor to create the other questions and answers for Figure 4 by using additional student responses to other one-minute papers.
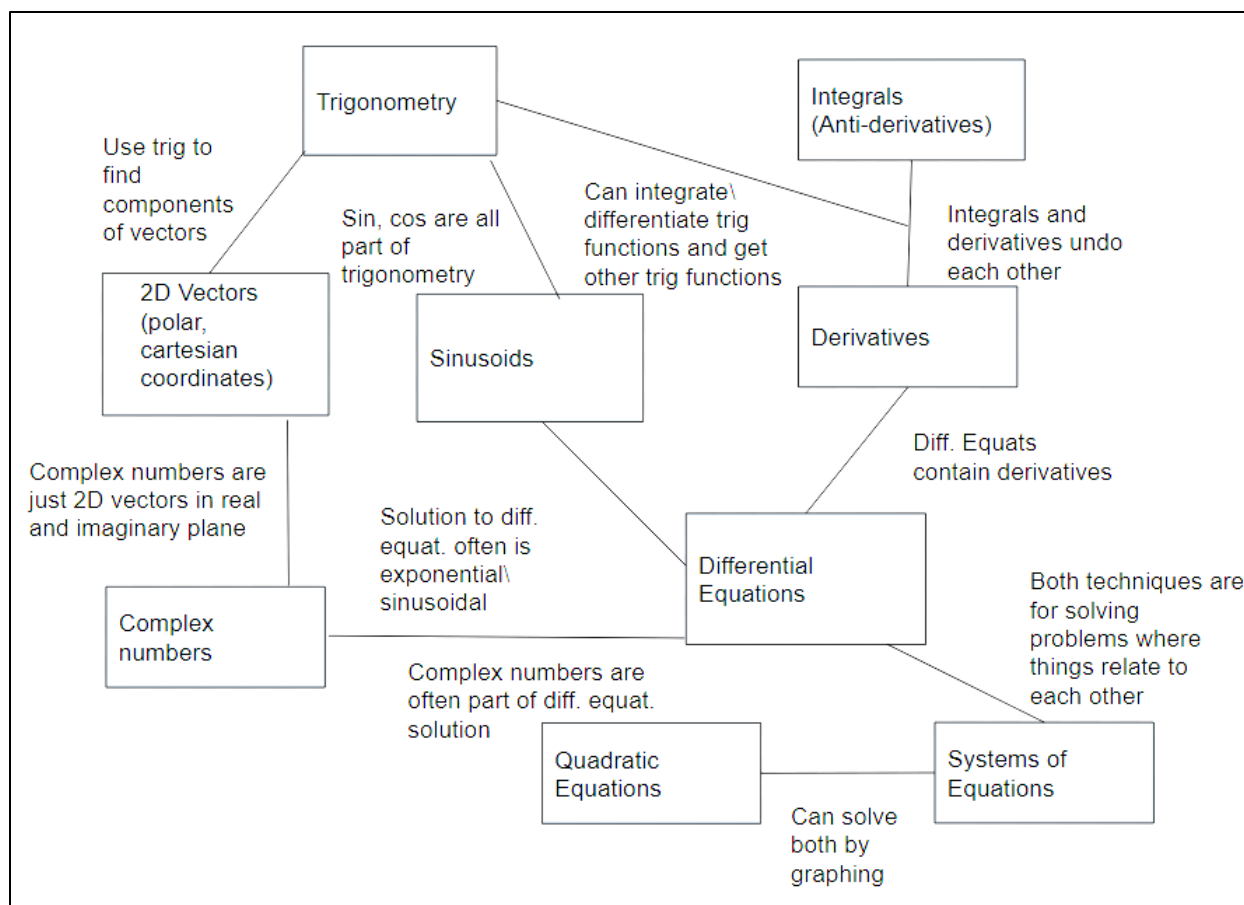
Figure 5: Sample Version of the Topic Flowchart

Based on student responses from Figure 3 and information in Figure 4, one of the student TAs created Figure 5, a topic flowchart. Figure 5 provides answers to student responses, like those posed in Figure 3. It also connects the information shown in Figure 4 to all other course topics. As previously mentioned, when creating the topic flowchart, the instructor encouraged the student TA to use simple terminology that first-year engineering students could easily understand.

Using exam wrapper data, the instructor led the class in a think-pair-share exercise to help students learn effective study strategies (Lyman, 1981). Student responses to open-ended survey items from exam wrappers were analyzed by students individually, discussed in pairs, and then they were discussed by the entire class. The activity focused on topics from the exam wrapper such as *what activities students used to prepare for the exam*, *whether or not they studied with others* and *how long they studied*. Throughout the semester, the instructor also provided students with electronic resources related to evidence-based study strategies. Below, Figure 6 shows how a student TA categorized exam wrapper data for the instructor to use when leading the think-pair-share activity.

exam 1 post test survey #1-3						
How They Prepared			**Studied With Others?**	**Time Spent**	**Where**	**Grade**
looked over notes	made review sheet		yes	few days	dorm study room	82
read chapters	completed practice problems	made review sheet	no	4 hours	dorm/library	83
completed practice problems			yes	4-5 hours	dorm study room	85
studied little bit of class materia	made review sheet		no	few days	dorm	72
looked over notes	made review sheet		no	2-3 hours	A^2	35
looked over notes	made review sheet		yes	7 hours	dorm study room	68
doing hw	reviewed quiz on same topics		yes	few hours	dorm	78
doing hw	reviewed quiz on same topics		yes	few days	dorm/library	93
practice exam	made review sheet	studied review sheet	no	few days	dorm	88
flash cards			no	3 hours	dorm study room	80
doing hw	completed practice problems		yes	few days	dorm study room/library	90
completed practice problems	read chapters		no	4 hours	dorm	97
completed practice problems			no	few hours	dorm	88
practice exam	completed practice problems		no	3 hours	library	73
made review sheet	flash cards		yes	4 hours	dorm	53
doing hw	looked over notes	practiced concepts	no	1.5 hours	dorm	75
doing hw	looked over notes		yes	4-5 hours	dorm study room	90
practice problems			no	few days	A^2	90
made review sheet	completed practice problems		no	few days	dorm, library	40
made review sheet	looked over notes		no	1.5 hours	dorm	80
made review sheet	looked over notes		no	2 hours	dorm	52
made review sheet	looked over notes	went to office hours	no	5-8 hours	dorm, library	65
completed practice problems	rewrote notes	doing hw	no	few days	dorm, UC, dorm study roo	83
doing hw	completed practice problems	made review sheet	no	few days	library	92
doing hw			no	few hours	dorm	58
completed practice problems	memorize formulas	looked over notes	no	few days	dorm	77

Figure 6: Sample Student Responses to an Exam Wrapper

Figure 6 classifies student responses to their first exam wrapper into several categories by color. For example, green shows that students prepared for the exam by using flash cards, rewriting notes and memorizing formulas. In addition, blue indicates students studied for the exam by reviewing quizzes, completing practice problems, doing HW, and finishing the practice exam. In the table, student responses also include: a) whether or not students studied with others, b) how long students studied, and c) where students studied on campus. Lastly, to compare students' exam grades to their responses from the exam wrapper, the student TA added the far right column.

Through midterm feedback, select students indicated *what about this course and/or the instructor's teaching of it most helps their learning:*

"When we give feedback"

"Doing examples on the board"

"The examples given in class and the clear step by step guide to the solutions"

"Explaining all the values and showing how he got those values as well as where they are plugged in."

"The instructor is very willing to stop class and answer any question we as students might have in relation to the lesson."

"The things that help me learn in this course is when [the instructor] works out the problems with us and allows, is available for help. He gives out informative hand outs and explains why the math we are doing is influential to the real world. Having the labs as well helps with hands on experience with different machines and giving us a better understanding of the program MATLAB which hasn't been covered in other classes yet."

Midterm feedback from students helped faculty identify helpful approaches to continue using throughout the remainder of the term. Faculty later thanked students for their anonymous feedback and discussed the collective responses with them in class. Following the midterm survey, students were still able to provide daily feedback about individual class topics/sessions via one-minute papers. Students also completed additional exam wrappers for remaining tests.

Discussion and Conclusion

A mid-sized private university in the Southeast has created an experimental first-year engineering course based on the Wright State Model for Engineering Mathematics Education. The course aims to increase student retention, motivation and success in engineering through an application-oriented, hands-on introduction to engineering mathematics. When compared to the traditional Wright State Model for Engineering Mathematics Education, the new course also focused on student communication (written, oral), teamwork, self-regulated learning and professionalism. The new experimental course also uses more frequent and formative assessment techniques. Faculty used Wright State's sample homework assignments to provide students with formative feedback and Wright State's sample exams to provide summative feedback. However, the format of the experimental course had faculty use more frequent and formative assessments to better understand what and how students learn the course content.

Preliminary qualitative data was collected from students via one-minute papers, mid-term evaluations, exam wrappers, and final course evaluations. Preliminary quantitative data was

gathered from student course grades and cumulative GPAs (CGPAs). Thus far, students taking the experimental first-year engineering course believe they gain confidence and skills such as problem-solving, time management, study habits, computer programming, as well as real-world applications of math and physics. Thus far, over 80% of students have earned a grade of C or better in the experimental first-year engineering course along with their pre-calculus or calculus class. More than 80% of students have also maintained a CGPA above a 2.0. This study is part of a larger overall assessment of an experimental first-year engineering course based on the Wright State Model for Engineering Mathematics Education at a mid-sized private university in the Southeast. Preliminary quantitative and qualitative data have been collected from the experimental course, but this paper will focus on qualitative data that has come from formative assessment techniques.

Using first-year engineering student data from one-minute papers, the instructor and student TA provided additional opportunities for students to learn important concepts. The instructor and student TA made necessary adjustments to the course through (a) reiterating important concepts at the beginning of subsequent class sessions, (b) creating and distributing a FAQs document, as well as (c) making and sharing a topic flowchart with students. Using student data from exam wrappers, the instructor led the class in a think-pair-share activity to help students learn effective study strategies. Lastly, midterm course feedback allowed first-year engineering students to share what helped them most to learn.

As this course helped students improve their math and engineering abilities, as well as understand real-world applications of the concepts they learned, it will be offered again for students who need it. Ideally, more sections of EGR_Math will be offered in order to better prepare additional students for introductory calculus and engineering classes. Other universities should consider offering a first-year engineering course based on the Wright State Model for Engineering Mathematics Education. Frequent and formative assessment techniques can be used to continually analyze and improve the course.

References

Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teaching* (2nd ed.). San Francisco: Jossey-Bass.

Boyer, E. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Eberly Center (2019a, February 4). *Exam Wrappers.* Retrieved from https://www.cmu.edu/teaching/designteach/teach/examwrappers/

Eberly Center (2019b, February 4). *What is the difference between formative and summative assessment.* Retrieved from https://www.cmu.edu/teaching/designteach/teach/examwrappers/

Hattie, J. (2009). *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. NY: Routledge.

Karen L. Smith Faculty Center for Teaching and Learning. (2019, February 4). *What is the Scholarship of Teaching & Learning (SoTL)?* Retrieved from http://www.fctl.ucf.edu/ResearchAndScholarship/SoTL/

Klingbeil, N. W., and A. Bourne. (2013, June). A National Model for Engineering Mathematics Education: Longitudinal Impact at Wright State University.In *Proceedings of the 2013 ASEE Annual Conference & Exposition*.

Klingbeil, N. W., R. E. Mercer, K. S. Rattan, M. L. Raymer, and D. B. Reynolds. (2004, June). Rethinking engineering mathematics education: a model for increased retention, motivation and success in engineering. In *Proceedings of the 2004 ASEE Annual Conference & Exposition*.

Klingbeil, N. W., K. S. Rattan, M. L. Raymer, D. B. Reynolds and R.E. Mercer. (2007). Engineering Mathematics Education at Wright State University: Uncorking the First Year Bottleneck. Retrieved from http://corescholar.libraries.wright.edu/knoesis/1032

Lyman, F. (1981). "The responsive classroom discussion." In Anderson, A.S. (Ed.), *Mainstreaming Digest*, College Park, MD: University of Maryland College of Education.

Ohland, M. W., A. G. Yuhasz, and B. L. Sill. (2004). Identifying and removing a calculus prerequisite as a bottleneck in Clemson's General Engineering Curriculum. *Journal of Engineering Education, 93*(3), 253-257.

Society for Teaching and Learning in Higher Education. (2019, February 4). *What is SoTL?* Retrieved from https://www.stlhe.ca/sotl/what-is-sotl/