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Implementing the Wright State Model First-Year Engineering Mathematics Course in a Startup School of Engineering

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Introduction

The Wright State Model was first implemented in 2004[3] with the goal of increasing student retention, motivation and success in engineering at Wright State University. "The Wright State Model approach begins with the development of a novel freshman-level engineering mathematics course, "Introductory Mathematics for Engineering Applications." Taught by engineering faculty, the course includes lecture, laboratory and recitation components. Using an application-oriented, hands-on approach, the course addresses only the salient math topics actually used in core engineering courses. … The result has shifted the traditional emphasis on math prerequisite requirements to an emphasis on engineering motivation for math, with a "just-in-time" structuring of the new math sequence." [2]

A new school of engineering, created at Campbell University in North Carolina, welcomed their first engineering class in the fall of 2016. "Introductory Mathematics for Engineering Applications" is taught to approximately a third of the first-year class during the fall semester. Because students enter their first-year with varied math backgrounds, the course is meant to help fill the gaps. In other words, every student enters their first year in a boat filled with holes. The course helps fill each hole so that at the start of the next semester, all boats can rise with the tide.

In addition, retention is necessary for the success of the new school. "Introductory Mathematics for Engineering Applications" is an integral part of the model which has a proven success rate of not only improving retention and consequently graduation rate but also improving self-efficacy of students with above average high school GPA's. It is believed that, "The hard workers make it through because the course helps them *believe* they can do it."[4] This was especially true for females who, "Felt more strongly that the course had increased their chances of success in engineering than did males. It helped them believe that they had chosen the right major, and the result was an even greater impact on ultimate graduation rates."[4]

Therefore, the purpose of implementing this course for the student is to fill mathematical holes and build self-efficacy that may ultimately help to build engineering identity, reduce fear-factor, and eliminate imposter syndrome. The purpose of implementing this course for the new school is to help with retention rate. To gauge the impact of the course, a survey was given to the students at Campbell University at the end of the semester. This paper contains the survey data from current (2017) first-year students and those who completed the course in 2016.

Background

For more information about the Wright State Model for Engineering Mathematics Education and the course, "Introductory Mathematics for Engineering Applications,"

developed at Wright State University, please visit the website.[2] The course material consists of a textbook, lecture notes and corresponding videos, complementary labs which can be performed hands-on or virtually, and the use of MATLAB assignments. All of which, except the textbook, can be found on the website.[2] Papers documenting the model and its success can also be found on the website.

The Wright State Model was designed for underprepared students and has had a "dramatic effect on first-year retention in engineering" at Write State University with an overall increase in retention from 68.0% to 78.3%. "The goal of the course (built around the model) is to address only the salient mathematics topics actually used in the primary core engineering courses, thereby fulfilling math prerequisite requirements within the context of a single course."[3]

Campbell University School of Engineering incorporated the course, "Introductory Mathematics for Engineering Applications," to help with retention and because it fit the school's vision of offering all engineering classes in a class-lab format vs. separate lecture and lab courses. The primary goal of this class-lab format is to incorporate hands-on activities throughout the curriculum to integrate content and application.[1] The school has also limited class sizes to a maximum of 24 students.

One faculty member taught the three-credit course the first year (2016) without a teaching assistant. There were two sections that met on Tuesdays and Thursdays for ~90 minutes each. It was determined that this was not enough time to cover lecture notes, include labs, give exams, and review homework and MATLAB assignments. Therefore, a two-hour, zero credit lab was added the following year (2017) that met on Wednesdays in addition to the 90 minute lectures on Tuesdays and Thursdays. The same faculty member taught the course, this time with the aid of a teaching assistant. There were approximately twelve, Wednesday lab sessions. Since there were two sections of the course, the sections alternated weeks in the beginning. However the separate lecture and lab format organically evolved back into a class-lab format as the semester progressed. Students from both classes enjoyed cross collaborating. The two sections were then combined and met weekly. When not conducting a lab, the time was used to cover lecture notes, and review homework and MATLAB assignments.

Table 1 lists the labs implemented in this course and referenced later. Details of the labs can be found on the website.[2]

Table 1: Labs performed during class

Lab	Title
1	Application of Algebra in Engineering - The One Loop Circuit
2	Trigonometry Relationships - One and Two Link Planar Robots
3	Sinusoids in Engineering - Measurement and Analysis of Harmonic Signals
4	Systems of Engineering - The Two Loop Circuit
5	Derivatives in Engineering - Velocity and Acceleration in Free Fall
6	Integrals in Engineering - Work and Stored Energy in a Spring

Data

All entering first-year students with an ACT of 24 or less were placed into "Introductory Mathematics for Engineering Applications." This course is primarily taught in the Fall semester, splitting the students into two sections based on class schedule. The same, female instructor has taught all four sections over the two-year period. Students in both sections (each year) were given the same material, same assignments, same labs, and same exams. Approximately half of the students from 2016 remained enrolled in engineering for the spring semester. Sixteen of the nineteen students in 2017 or 84% remained enrolled in engineering for the spring semester.

Table 2: Demographics

Year	Sample Size	Male	Female
2016	33	30	3
2017	19	18	1

The survey was obtained from Wright State University. Question 8, Part II and the two final questions were added by the author.

In Part I of the survey, students responded to the following open-ended, short answer questions.

1. What is the highest level math class you completed in high school?
2. What is the highest level math class you have completed in college?

The majority of students had completed some form of calculus in high school. All students were concurrently enrolled in College Algebra, Pre-Calculus, or Fundamentals of Math.

In Part II of the survey, students responded to the following questions using a Likert Scale of 1-5: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree. The average for each question is shown in Table 3. Questions 1 and 3 represent the impact of the course on student self-motivation. Questions 2 and 4 represent the impact of the course on student self-efficacy.[4]

Questions

1. The course has increased my motivation to study engineering.
2. This course has increased my chances of success in engineering.
3. This course has increased my motivation to study math.
4. This course has increased my chances of success in future math courses.
5. The office hours aided my understanding of the lecture material.
6. The lab sections aided my understanding of the lecture material.
7. Application of MATLAB was a valuable component of this course.
8. This course makes me feel like an engineer.

Table 3: Part II – Survey Results

Question	Average 2017	Average 2016
1	4.4	4.3
2	4.5	4.3
3	4.4	4.4
4	4.5	2.9
5	4.3	3.3
6	4.1	4.3
7	3.1	4.3
8	4.2	*

* Did not ask this question of the 2016 group.

For question four, an average of 2.9 in 2016 vs. 4.5 in 2017 is a marked improvement. The author is not certain why the average in 2016 was so low however, the loss of half of the students from the fall to the spring semester might indicate that their were many students who were undecided and therefore, uncommitted.

In 2017, we hired a teaching assistant who held a minimum of five office hours per week. This student had taken the course in 2016 and had performed very well. The 2017 students related well to him and found him extremely helpful as reflected in the increase from 3.3 to 4.3 on question five.

MATLAB was well received until the chapter and assignment on functions. Only one or two students from the 2017 class had prior programming experience so learning the concept of a function, calling a function, and returning results to the main function was a steep learning curve in a very short amount of time. This may account for the drop in average from 4.3 in 2016 to 3.1 in 2017.

One of the outcomes that the new school of engineering hopes to achieve is to help students identify as an engineer. This course appears to be helping with this goal with an average of 4.2 in 2017. Unfortunately this question was not asked of the 2016 group and therefore there is no comparison.

In Part III of the survey, students responded to the following questions using a Likert Scale of 1-5: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree. The average for each question is shown in Table 4.

1. I have spent considerable time researching to decide on my career of choice.
2. I chose my career based primarily on what I feel I am good at doing.
3. I chose my major based primarily on what career I see myself entering after graduation.
4. I felt pressure to pick my major even without fully knowing my career options.
5. I am certain of what career I will be entering when I graduate.

Table 4: Part III Survey Results

Question	Average 2017	Average 2016
1	3.9	4.3
2	4.2	4.3
3	4.4	4.4
4	2.3	2.9
5	3.6	3.3

Finally, students were asked which lab they felt was the most helpful and which chapter was the most helpful. In 2017, Lab 1 was performed hands-on in class while Labs 2-6 were done virtually during class. The primary reason that students liked Lab 1 was because it was hands-on. The students considered Lab 5 to be the next most helpful. The students found Chapters 4 and 8 to be the most helpful. [See comments in Appendix.]

Discussion

The intent of incorporating the Wright State Model first year course, "Introductory Mathematics for Engineering Applications," at Campbell University was to fill mathematical holes and build self-efficacy that may ultimately help to build engineering identity, reduce fear-factor, and eliminate imposter syndrome in students while helping ensure a higher retention rate in engineering in order to build the new program. The model also fit perfectly into the new school's vision of offering a class-lab experience with hands-on labs supplementing lecture.

The course was not included in the curriculum with the intent to "weed" out students, but with the intent to "weed in" students. Engineering is daunting to many students and this course helps to reduce the fear factor of math and engineering, build self-efficacy and improve self-motivation as evident by a 4+ average on the questions 1-4 in part II. The students felt the labs were helpful with a 4.1 and 4.3 average respectively per year and those in 2017 felt that the course helped them identify as engineers with an average of 4.2 on question 8 in part II.

Future work will include comparing the success of students who took this course to those who "placed out" of it by comparing course grades in higher level engineering courses, gpa and graduation rate. Future work will also include tweaking the survey to obtain more specific data.

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Appendix

Part 1 Data 2017:
Math 111 = Algebra, Math 110 = Pre-Calculus, Math 100 = Fundamentals of Math

Student	2017 Question 1	2017 Question 2	2016 Question 1	2016 Question 2
1	Pre-Calculus	Math 110	Algebra	Math 110
2	Pre Calculus	Math 100	Math 3	Math 111
3	Calculus	Math 111	Pre-Calc	Engr 110
4	Calculus	Math 111	Calc AB	Math 111
5	Intro to College Math	Math 111	AFM Advanced Functions and Modeling	Math 100
6	AP - AB Calculus	Math 111	Pre-Calc	Math 100
7	AP Calculus	Math 111	AB Calc	Math 111
8	Calculus	Math 111	Calculus	N/A
9	ICM	Math 110	Algebra 3 Trig &Stats	Math 111
10	Pre-Calculus	Math 100	Statistics	Algebra 3
11	AFM	N/A	AFM	Math 110
12	AFM	Math 110	Algebra 2	Algebra Precalc
13	AFM	Stats	Pre-Calc	Math 111
14	AP Calculus	Math 111	Pre-Calc	Math 110
15	Pre algebra	Math 111	Calculus	ENGR 110
16	Calc 1	Math 100	Analysis of Functions	Math 111
17	Pre Calculus	Math 111	AP Calc	None
18	Pre Calculus	Math 110	AP Calc BC	Modern Abstract Algebra
19	Algebra	Engr 110	Discrete	Math 111
20			Honors Discrete	N/A freshman
21			Pre-Calc	Math 111
22			AB Calc	Math 111
23			AP Calc	Math 111
24			IB Math	Math 111
25			Pre-Calc	Math 100
26			Algebra 2	Math 100
27			Basic math	Statistics
28			Algebra	Math 110

Part 2 Data 2017

Question	Average 2017	Strongly Agree 5	Agree 4	Neutral 3	Disagree 2	Strongly Disagree 1
1	4.4	10	6	3	0	0
2	4.5	12	5	1	1	0
3	4.4	11	5	2	1	0
4	4.5	10	9	0	0	0
5	4.3	10	5	3	1	0
6	4.1	5	12	1	1	0
7	3.1	3	4	5	5	2
8	4.2	7	9	2	1	0

Part 3 Data 2017

Question	Average 2017	Strongly Agree 5	Agree 4	Neutral 3	Disagree 2	Strongly Disagree 1
1	3.9	6	7	5	1	0
2	4.2	6	11	1	1	0
3	4.4	10	7	2	0	0
4	2.3	1	1	5	8	4
5	3.6	5	5	7	1	1

Comment 1 Data 2017 ** Question not asked of 2016 students

Student	Questions: Which Lab was the most helpful?
1	Two Link Robots because I was confused on the subject at first but the visual lab opened my mind up to better understand.
2	Labs dealing with derivatives or integrals
3	Lab #1 was helpful because it helped me understand how a breadboard works. It was also the only hands on lab.
4	Lab 5 the display of graphs helped me to better understand the content.
5	Honestly I can't recall which helped the most but I did enjoy the virtual labs. They were easier
6	Lab 1 because it was hands on and it taught me how to make circuits.
7	Lab 1 being it was the most hands on and allowed to realize what a circuit was.
8	Lab 5 helped with derivatives
9	Lab 4 I believe with the derivatives
10	All of them better my knowledge
11	Any of the virtual labs helped me a lot just for using the computers.
12	Lab 1 because it was hands-on
13	The first lab we used the online portion. It helped me see what the graph looked like and where the lines was at.
14	I think Lab 1 because that’s where I first got a understanding of the labs and what we were supposed to do.
15	Lab 1 because I got to use the tools in front of me

16	Lab 5 because I learned Excel
17	The circuits one because I will need it for the future.
18	Lab 3 because it enhanced my skills on MATLAB
19	I'd have to say it was the matrix algebra lab. It was able to compliment what I learned in class and further my understanding

Comment 2 Data 2017 **Question not asked of 2016 students

Student	Question: Which Chapter was the most helpful?
1	Systems of equations was very helpful because I learned and understood this chapter the best, and it boosted my confidence due to me knowing the material.
2	Chapter 4-9
3	The chapter on matrix algebra was helpful to me because it helped me understand some codes for MATLAB
4	Chapter 2 because before this chapter I never understood how to factor.
5	Chapter 2 helped
6	Chapter 8 because as I move up in math like calc, I'm going to be doing a lot of those and since we did them in here it has given me a better understanding of them.
7	Derivatives, it had been a while from the last time I had done them so it was a nice refresher
8	Chapter 7 and 8. I need help with derivatives.
9	The 3rd chapter. I enjoyed it the most. I love planar.
10	All helped me learn and pass the class.
11	Chapter 6. I enjoyed matrix algebra and I enjoyed how easily I caught on to the work.
12	Chapter 8 was most helpful because I learned a formula that I will need to know for the future.
13	The matrix from chapter. It jus added more ways to try things and figure out the answer.
14	Chapters 1,2,3 because I have seen those in other classes this year.
15	Chapter 4
16	Derivatives because it helped me understand it even better.
17	All the chapters were helpful but the later ones were hard.
18	Chapter 8 because it requires concentration and time
19	I believe chapter 3 was the most helpful because it was a base line for the rest of the chapters.