Implementing Engineering Mathematics in the CEAS

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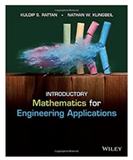
What is GEEN3830: Engineering Math?

- CEAS implementation of the Wright State Model for Engineering Mathematics Education
- Covers fundamental concepts from Calculus 1, 2, 3 & Differential Equations in one semester, motivated by engineering applications + one Data Science/CS activity
- Utilizes hands-on active-learning laboratory experiences to immerse students with authentic engineering equipment and practices
- 10+ years of research at Wright State show boosts in student performance and retention, with ***replication*** underway at multiple national sites



WRIGHT STATE UNIVERSITY

MWF Lecture Content (Chapters in Rattan & Klingbeil)	Tu Recitation Th Lab
Course Intro	
Linear & Quadratic Equations (Ch.1 & 2)	*Lab 0: Intro and Setup*
Trigonometry (Ch3)	*Lab 1: One-Loop Circuit*
More Trig (Ch3)	*Lab 2: One and Two-Link Robots*
2-D Vectors in Engineering (Ch4)	*Lab: MATLAB Activity 1*
Complex Numbers in Engineering (Ch5)	*Lab Catch-Up & Review*
Sinusoids and Harmonic Signals (Ch6)	*Lab 3: Harmonic Signals*
Systems of Equations and Matrices (Ch7)	*Lab 4: Two-loop Circuit*
Derivatives in Engineering (Ch8.1-8.2)	
Derivatives in Dynamics (Ch8.3)	*Lab: MATLAB Activity 2*
Derivatives in Electric Circuits (Ch8.4)	*Lab: MATLAB Computer Science 1*
Derivatives in Mechanics of Materials (Ch8.5-8.6)	*Lab 5: Velocity and Acceleration*
Integrals in Engineering (Ch9.1-9.2)	
Integrals in Statics (Ch9.3-9.4)	*Lab: MATLAB Activity 3*
Integrals in Dynamics (Ch9.5)	*Lab 6: Work and Energy in Springs*
Integrals in Electric Circuits (Ch9.6-9.7)	
(more integrals in engineering Ch9.8)	*Lab: MATLAB Computer Science 2*
	KAT
Diff Eqs in Mechanical Systems (Ch10.3)	
Diff Eqs in Electrical Systems (Ch10.4)	*Lab 7: The Leaking Bucket*
Applications of Diff Eqs (Ch10.5)	*Lab 8: Spring-Mass Vibration*

"The Wright State Model for Engineering Mathematics Education," *College of Engineering and Computer Science | Wright State University*, 2017. [Online]. Available: https://engineering-computer-science.wright.edu/research/engineering-mathematics/the-wright-state-model-for-engineering-mathematics-education.

Sample Course Content: Sinusoids

Lecture: Sinusoid properties including amplitude, period, frequency, phase shift. Graph, scale, transform sinusoids and perform sinusoidal addition.

Lab: Measure waveforms using oscilloscope directly from function generator, Measure waveforms using oscilloscope based on student-built LC & RC circuits, Plot results in MATLAB and observe sinusoidal addition!

Recitation: Review sinusoids in small group, active learning environment with Learning Assistants & Teaching Assistants.

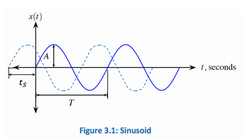


Figure 3.1: Sinusoid

Figure 3.2: Symbol and Physical Examples for Inductors

Figure 3.3: Symbol and Physical Example for C

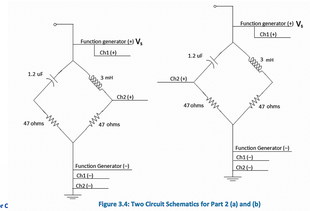


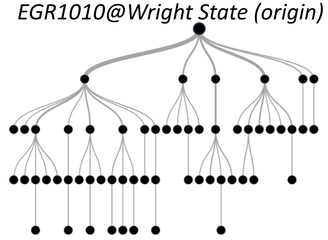
Figure 3.4: Two Circuit Schematics for Part 2 (a) and (b)

Replication vs. Mutation of a "Proven" National Model

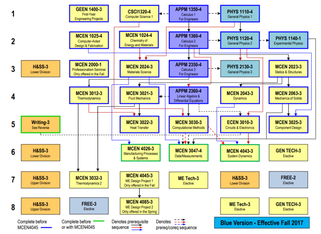
WSM Model requirements:

1) GEEN3830 ***counts*** towards graduation
2) GEEN3830 ***counts*** as a pre-req to courses in engineering majors

EGR1010@Wright State (origin)



Sample CEAS Curriculum (no GEEN3830):



Here, course ***counts*** only for specific requirements in specific majors for specific people who must petition for specific permission!

Engineering Math Lab: ECES1B12

The room we were given access to has brought a lot of memories. One of the more notable ones was 'Adrian's office hours.' I will never forget the 3:00 AMs with the legend himself who never ceased to amaze me with his ability to pull consecutive all nighters.

~ Tomas, Y1 Reflection Question 7, Week 15

Engineering Math Pioneers: Y1 cohort

Quantitative Measures

Enrollment & Demographics of students across Y1 & Y2 (Y3 waiting for census)

	Students in Engineering Math		Comparable First-Year Engineering Cohort (Y2)
	Y1	Y2	
Enrollment	N=22	N=101**	N=818
In-state residents	91%	61%	61%
International	5%	11%	5%
Women	36%	55%	37%
Underrepresented minority	82%	39%	16%
Low income	73%	34%	15%
First-Generation college	59%	34%	12%
GoldShirt Program participant	59%	35%	1%
ACT Math Min	20	20	23
ACT Math Max	28	33	36
ACT Math Avg/Median	25/25	25/25	31/32
High School GPA Avg	3.77	3.79	3.93

*** N =101 in Y2 reflects only students who completed the course and received a grade (students who withdrew or dropped the class are not included in this analysis)*

- **Y1: Fall 2017, 22 completed GEEN3830**
  Suggested for students concurrently enrolled in APPM1235
  Avg Semester 1 cumulative GPA = 3.11
  As of Spring 2019, 86% are still at CU (n = 19), 82% still ENG (n = 18)
  ENG at CU, Avg Semester 3 cumulative GPA = 2.91
  ENG at CU, Avg Semester 4 cumulative GPA = 2.87
- **Y2: Fall 2018, 99* completed GEEN3830**
  Required for students concurrently enrolled in APPM1235 or APPM1340
  Average GEEN3830 course grade = 2.69 for 99 completers
  9 students got D's or F's in Y2, 11 withdrew → Total 20/110* = 18% DFW in Y2
  Avg Semester 1 cumulative GPA:
  2.75 for n = 99 Y2 completers
  1.93 for n = 11 students who withdrew from Y2 course
  2.78 for n = 33 engineering students simultaneously enrolled in Pre-Calculus who were never enrolled in the Y2 pilot
  Avg Semester 2 cumulative GPA = 2.68 for n = 99 Y2 completers
- **Y3: Fall 2019, current enrollment = 105**
  Required for incoming first-year students concurrently enrolled in APPM1235, APPM1340, MATH1150 or MATH1300

** n = 99 vs. 101 reflects two retroactive drops following quantitative data analysis*

Ongoing Research Directions & Questions

1. What are the consequences of *Mandatory but not Required* course status on students, instructors, advisors, etc.?
2. How can we sustainably scale a high-touch program?
3. Are we mindfully creating *counterspaces* for our vulnerable populations?
4. What is the ethical responsibility for educational innovators – is batch-enrolling incoming 1st-year students into a 4-credit course "fair"?
5. Observing differential drop rates for men vs. women through week 4 of Y3 pilot?
6. Concerns regarding differential course grades for Y2 students consenting vs. non-consenting to research participation: n = 63 consenting (83.9% avg grade) vs. n = 37 declined (74.3% avg grade)?

Future Implementation Decisions

- Course name and course number going forward?
- Continue to batch-enroll students not placed into Calc 1 into the course?
- How to best advise students and message them about a non-traditional, mandatory but not required class to incoming students?

Data Collection & Assessment Plan

1) Quantitative Tracking of Student Performance Variables
   - Performance in concurrent math course (APPM1235, APPM1340, MATH1150, or MATH1300)
   - Comparison to Direct Admit Engineering students not at Calc 1-level but not enrolled in GEEN 3830
   - Longitudinal Tracking:
     - Subsequent performance in engineering and math courses
     - Status, persistence & eventual retention in CEAS majors or other majors

2) Pre- and Post-Survey Data from students enrolled in GEEN3830
   - Belonging at CU, in the CEAS, in engineering and math courses
   - Math self-efficacy
   - Engineering identity, perceptions, and attitudes

3) Qualitative Analysis:
   - Individual course reflection assignments
   - Interviews with students who dropped class
   - Focus Groups & Interviews with students who completed GEEN3830

Qualitative Data Samples

Word Cloud from Y2 End-of-Semester Student Feedback

What I found really fascinating is that, I remember in my first office hour visit, almost the entire class was there to do homework, and so **we all got to know each other, we helped each other – it was a lovely environment, I really loved that**. Everyone was so supportive, we all became friends, basically, we helped each other – it was amazing. No other class gave me this experience – I really loved that.

~ Omar, pseudonym, Y2 student who dropped after week 5

The [Engineering Math] class itself was ridiculous, as the workload that came with it was equivalent to any two of my other classes combined. AND it's required to take Physics 1 for a person taking a yearlong calculus 1 class! I think that's ridiculous. I might have a different opinion on the class if I wasn't required to pass it. **I'd rather sign up for hell than get drafted into it** [the Engineering Math class].

~ Anonymous student, comment from end-of-semester FCQ, emphasis added

Engineering is a very hard major, and I have only completed one semester. However, I heard from a lot of students over the semester that they wanted to transfer from the engineering school, but as the semester is ending, **all of those students feel so accomplished and want to continue because they realized they could do it**, including me. It really is hard and it makes you want to quit so many times but **just wait because it is so rewarding**.

~ Jennifer, pseudonym, Y2 completer

Related Publications

[1] J. Y. Tsai, B. A. Myers, J. Sullivan, D. Reamon, K. Anderson, and K. O'Connor, "Scaling Up or Scale-making? Examining Sociocultural Factors in a New Model for Engineering Mathematics Education," in ASEE Conference Proceedings, Salt Lake City, UT, 2018.
[2] J. Y. Tsai, K. O'Connor, B. A. Myers, J. Sullivan, D. Reamon, and K. Anderson, "Examining the Replication – or Mutation – Processes of Implementing a National Model for Engineering Mathematics Education at a New Site," in ASEE Conference Proceedings, Salt Lake City, UT, 2018.
[3] J. Y. Tsai and B. A. Myers, "Mandatory but not Required: Examining Change in the Year Two Implementation of a Novel Engineering Mathematics Course," in ASEE Conference Proceedings, Tampa, FL, 2019.
[4] J. Y. Tsai, B. A. Myers, J. Sullivan, and K. Anderson, "Intended & Unintended Consequences of Rapidly Expanding an Engineering Mathematics Intervention for Incoming First-Year Students," in ASEE Conference Proceedings, Tampa, FL, 2019.
[5] A. Bielefeldt, J. Y. Tsai, B. A. Myers, and J. Sullivan, "Minority Status and Belonging: Engineering Math as a Vehicle to Build Community," the Collaborative Network for Engineering and Computing Diversity (CoNECD), Crystal City, VA, 2020.

Thank you

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