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WIP: The Evolution of an Engineering Mathematics Course: Integrating Student Feedback in Design and Implementation

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Abstract

A two-course sequence in engineering mathematics was developed at the University of Miami's College of Engineering as part of a broader curriculum initiative to integrate linear algebra, vector calculus, and differential equations with an emphasis on engineering applications. The redesign was driven by student and faculty feedback calling for more applied, less proof-based instruction.

The courses were collaboratively designed by faculty, students, and an instructional designer using backward design and Fink's Significant Learning Outcomes. A student focus group informed key elements, including low-stakes assessments, online homework with feedback, structured study sessions, and undergraduate teaching assistant support.

The pilot course was launched in Fall 2024 with 31 students. Actionable student feedback was prioritized, and a mid-semester evaluation was conducted. Based on the responses, the course was adjusted to include increased homework attempts, more frequent practice problems, and dedicated class time for complex concepts. Student feedback also highlighted the value of in-class problem-solving, teaching assistant support, and low-stakes weekly quizzes. Additional student input came from weekly meetings with the two undergraduate teaching assistants, which gave the instructor valuable insights into the aspects of the course that students find challenging.

As the second course in the sequence is currently being taught in Spring 2025 with the same group of students, future efforts will assess the long-term impact on student performance, comparing outcomes with students in traditional math tracks. Continuous improvement will be supported through summer course reviews using student feedback and performance data to refine instruction and better align content with engineering needs. This student-informed, application-focused approach aims to foster deeper understanding and long-term success in engineering coursework.

Introduction

As part of a curriculum initiative at the College of Engineering at the University of Miami, a new required two-course sequence in engineering mathematics has been developed to integrate topics from linear algebra, vector calculus, and differential equations with a strong emphasis on engineering applications.

The curriculum change was prompted by student and faculty feedback, specifically regarding the desire for more engineering-specific applications, shifting the emphasis from proof-based mathematics to a more applied approach. This aligns with curricular changes implemented by other institutions who have similarly cited the need for a more practical approach to mathematics education for engineering students [1] [2]. Moreover, a widely studied application-oriented model for teaching mathematics has shown positive impacts on student retention, motivation and success in engineering programs [3].

This paper describes the course design process emphasizing the significant role of student input and continuous student feedback in the design and implementation of the first course in the sequence. The pilot course launched in Fall 2024 with an enrollment of 31 students. Eligibility for the course required the completion of Calculus I and Calculus II. During pre-registration advising, eligible students were presented with the option to enroll in this pilot course or continue with the mathematics course mandated by their respective majors. Students represented five of the six academic departments within the college, with the majority (86%) originating from two departments.

Course Design Process

Recognizing that the College of Engineering at the University of Miami has a diverse student body with students from various backgrounds and different learning experiences, a collaborative approach to the course design process was essential in creating a course that would meet the needs of all students.

Therefore, this course was developed through a collaborative design process involving a select group of engineering faculty that included the course instructor, students and an instructional designer. Beginning in Spring 2024, the instructor partnered with the instructional designer to develop the course, drawing on backward design principles and Fink's Significant Learning Outcomes [4] [5]. To ensure the course was responsive to student needs, a focus group of seven undergraduate engineering students was facilitated. The results of this focus group are discussed in more detail in the next section.

To further ensure that the needs of all engineering students would be met, a faculty committee was formed. This committee, led by the associate dean of undergraduate studies, included representatives from each academic department, the course instructor, and an instructional designer. The committee was tasked with reviewing the course content, and defining the essential mathematics knowledge needed for successful engineering coursework. This allowed for diverse perspectives to be considered and incorporated into the design of the course.

This committee met several times over the course of the Spring semester and provided feedback on the sequencing of topics, ensuring alignment with prerequisite knowledge and future coursework in different engineering disciplines. This helped to design a course that would minimize learning gaps and enhance students' overall understanding.

In addition to this, the course instructor actively sought feedback from faculty across different engineering departments by attending various department meetings. By allowing for the inclusion of diverse perspectives into the design process, the instructor prioritized creating a learning experience that would be both engaging and impactful for students.

This holistic approach to the course design process helped to ensure that student learning outcomes and engagement were at the center of the design process. The combination of backward design and Fink's Significant Learning Outcomes was meant to help foster a deeper understanding of the concepts, by first clearly defining the learning outcomes and then considering how to make those learning outcomes more meaningful and impactful.

Incorporation of Student Input and Feedback on the Course Design and Implementation

1. Student focus group

In Spring 2024, the instructor and instructional designer engaged with a focus group of seven undergraduate engineering students. These students represented three of the six academic departments within the college. Four students had completed all four major-specific required mathematics courses, while three students were currently enrolled in the third required mathematics course.

The purpose of this focus group was to gather information regarding instructional practices that students found helpful for learning. Through open-ended questions, the group explored teaching modalities, assessments, instructor perceptions, their self confidence in mathematical skills, and real-world applications of learned concepts.

The focus group findings revealed three key factors influencing students' positive experience in math courses: (1) an organized and well-structured learning environment with timely feedback, frequent low-stakes assessments, and multiple opportunities for demonstrating learning; (2) robust support systems from the instructor and university, including dedicated discussion/recitation sessions, accessible tutoring services, and pre-exam review sessions; and (3) being able to make a connection between mathematical concepts learned in class and their application in engineering coursework.

Based on the findings from the focus group, the following elements were incorporated into the design of the course:

- Undergraduate teaching assistant support to facilitate during in-class problem-solving sessions
- Online homework assignments featuring multiple submission attempts and immediate feedback provided upon final submission to allow students to learn from mistakes and improve understanding
- Low-stakes quizzes primarily assessed on completion to reduce the pressure associated with grades

- Optional bi-weekly study halls facilitated by the undergraduate teaching assistants to provide peer-to-peer learning opportunities and enhance student support
- Study guides with answer keys in preparation for all summative assessments

2. Mid-semester survey

To gather student perspectives, an optional, anonymous mid-semester survey was administered in Fall 2024 to assess specific aspects of the course. The survey also included prompts that encouraged students to reflect on their current challenges, positive learning experiences, and provide suggestions for course improvement. A strong response rate of 74% (23 out of 31 students) was achieved.

Survey results indicated that 100% of respondents agreed or strongly agreed that problem solving in class helped them work problems on their own. They valued having dedicated time for problem solving in class: “The in-class practice problems where we can try and then see each step worked through. This helps set a foundation for doing the online hw”, “I really like being able to work through problems in class where it is not just a lecture. I like that we are able to work with classmates, the professor, and the TA's”.

The optional study hall was also mentioned as a positive aspect of the course: “I like the study hall hours because they encourage me to do the homework ahead of time”, “Study Halls have worked out well for me personally. It feels like I have a set time to do homework in this class and I commit to it. Much better than if I hadn't had the obligation of study halls to go to”. All respondents who had attended study hall sessions (57%) were planning to continue attending.

The majority of reported challenges were related to specific topics, such as linear independence of vectors and Kirchhoff’s Law. Additionally, 13% of respondents cited the lecture pace as being too fast.

In response to these insights and suggestions, several immediate course adjustments were implemented. These included an increase in the number of attempts allowed for homework assignments, a reduction in the pace of instruction, and the establishment of a consistent weekly homework deadline.

3. Weekly meetings with undergraduate teaching assistants

The instructor conducted brief weekly meetings with the two undergraduate teaching assistants. These informal discussions centered on reviewing the week's material, analyzing assignment outcomes and student engagement in study hall, and pinpointing areas where students encountered difficulties. Furthermore, the instructor actively solicited specific feedback from the teaching assistants regarding the in-class instructional approach. In response to these meetings, the instructor dedicated additional class time to reviewing topics that were proving challenging to the students.

4. End of semester small group feedback session

Towards the end of the semester a small student focus group was held with two students and the two teaching assistants to gather qualitative feedback. The questions asked during the session were centered on participant experiences with the teaching methods, assessment strategy and course resources. Participation in the focus group was voluntary, and the low turnout which was possibly due to scheduling conflicts, limits the generalization of the findings and may reflect the perspectives of participants who were very engaged in the course. However, the discussion provided valuable insights that largely reinforced the quantitative data from the mid-semester survey, as participants valued the approach of combining lectures with problem-solving sessions, dedicated study hall hours and accessible support from the teaching assistants. Participants also highlighted the positive impact of having the opportunity to learn from their mistakes and the emphasis on mastery rather than grades.

Future Work

As the second course in the sequence is currently being taught in Spring 2025 with the same group of students, future work will focus on evaluating whether the courses are equipping the students with the necessary mathematical skills to succeed.

First, student progress will be tracked until graduation to understand the long-term impact of the course, more specifically if the knowledge acquired has been beneficial to subsequent engineering coursework. A variety of methods like focus groups, surveys and interviews with students and faculty will ensure a thorough understanding of student experiences and the effectiveness of the courses. Additionally, the academic performance of students who participated in this course sequence will be tracked in a specific subset of subsequent engineering courses. This will allow for comparison to the performance of students who completed the traditional proof-based mathematics courses in the same subject areas. As these insights are gathered they will be continuously incorporated into the courses and used to adjust the topics taught to better align the mathematical needs of engineering courses.

Secondly, to further ensure continuous improvement, a comprehensive review of the courses will be conducted over the summer to allow for timely adjustments and improvements before the courses are offered again, ensuring that the courses remain effective and aligned with the evolving needs of the students. This review will involve analysis of student performance data and student feedback from both semesters to identify key areas for improvement and achievement of course-specific learning outcomes.

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