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Engineering Faculty Perceptions of and Responses to Student Math Readiness

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Engineering Faculty's Perceptions of and Responses to Student's Math Readiness

Abstract

This paper explores the perceptions of engineering faculty on students' math readiness and how they respond to it. Prior research shows that introductory math courses often challenge early college students, and students struggle with both understanding and application of mathematical concepts. Additionally, the existing literature has not examined how faculty respond to students' lack of math readiness. To better understand this issue, this study examines engineering faculty's perceptions of and responses to students' math preparedness. The study utilizes interview data collected at two institutions – one private R2 and one public M1 university. A preliminary analysis of seven interviews suggests that faculty perceive that students struggle with understanding math concepts required in engineering courses, performing computations, moving between different mathematical representations, and applying math concepts to engineering problem solving. Faculty primarily respond to this issue by devoting class time to helping students with math concepts and highlighting how math concepts are applied to engineering domains. Additionally, faculty provide out-of-class support to students and encourage peer learning to address this issue. Some also avoid using advanced mathematical concepts in their courses.

1. Introduction

In engineering students' early college experience, math courses often pose a point of struggle. While some students see them as a "gateway to engineering", others view them as "gatekeepers" [1]. Math courses, particularly, calculus-focused courses, are often perceived with both scaffolding and litmus properties, which on one hand, prepare students for their higher-level STEM education and, on the other, filter them out [1], [2]. However, the effects of filtering are felt more prominently than those of scaffolding [2]. Hence, these math courses often lead to high dropout rates in the initial years and continued challenges in the later years through application-related difficulties encountered by students.

Another issue that exacerbates engineering students' experiences in introductory math courses is that they often do not display high levels of subject knowledge coming into higher education, struggling with basic algebra, geometry, and trigonometry [3]. This trend is visible both in their first and second years. For example, in a study conducted at a university in the United States, first-year students, when assessed on mathematics skills required for their introductory engineering courses, struggled to apply several basic mathematical operations such as interpreting graphs, calculating volumes of select structures, and understanding complex numbers. Similarly, sophomore students struggled with matrix multiplication and vector operations, concepts required for their higher-level engineering courses [4].

Prior studies that examined engineering faculty's perception of students' math readiness also found that faculty perceive that students struggle with applying mathematics concepts in their engineering courses. Faculty perceive students as not being able to adequately demonstrate mathematical ability in several areas including units and dimensions, creating and interpreting graphs, performing algebraic manipulation, and knowing when to use calculus concepts [5]. Additionally, engineering faculty believe that students do not display effective mathematical communication skills and “adhere closely to fixed, recipe-like thinking” [6, p. 6] highlighting that students reject uncertainty and expect extremely precise results.

A major cause of engineering students’ struggles with math courses is their perceived lack of connection between math and engineering. Students often do not see the relevance of studying math in the early years of the degree. As a consequence, they find it difficult in the later years to apply the math concepts learned in the introductory math courses [7].

To address the issue of relevance, several initiatives have been implemented to better integrate mathematics within engineering programs. These initiatives focus on teaching math courses in a way that integrates engineering-specific problem solving or technology. The Curriculum Renewal Across the First Two Years (CRAFTY) project documents several such approaches in the fields of mechanical, civil, electrical, and chemical engineering [8].

The success of these programs, however, often depends on faculty engagement. Furthermore, changing engineering and mathematical curricula requires significant resources and effort. Hence, universities are not always able to make changes to the existing courses and curricula, especially because programs that integrate math and engineering are not a guaranteed success [9]. As a result, universities generally tend to continue with math courses being entirely taught by math departments. Consequently, engineering faculty need to work with students who either struggle with math concepts or find it difficult to apply these concepts within the context of engineering courses.

This paper aims to capture engineering faculty’s perceptions of and responses to students’ math readiness in their courses. The following questions guide the study:

> ***RQ1: How do engineering faculty perceive students’ math readiness in the context of the courses they teach?***
> ***RQ2: How do they respond to students’ math readiness?***

Through the findings of this study, we seek to document common student struggles with mathematics as well as how faculty members address these issues. These findings will help both engineering faculty and administrators with strategies to support students in engineering courses, especially when they struggle with math concepts.

The unique contribution of this work comes from its exploration of how engineering faculty address students’ math readiness in their courses. Prior studies have highlighted engineering students’ struggles in specific topic areas or math competencies (e.g., see [5], [6], [10]). However, this literature does not focus on how faculty navigate their teaching considering student struggles. By mapping faculty responses to student struggles, we aim to highlight the specific approaches that are commonly utilized to combat persistent issues.

2. Conceptual Framework: KOM Competencies

To address the research question guiding this study, we will use the KOM competencies (English translation: “Competencies and Mathematical Learning”) as the conceptual framework [11]. This framework specifies eight different mathematical competencies, and defines a mathematical competency as “*a well-informed readiness to act appropriately in situations involving a certain type of mathematical challenge*” [11, p. 49, *italics* in original]. These competencies cover two broader capabilities: 1) asking and answering mathematical questions and 2) working and communicating with mathematical language and tools. While competencies can overlap in that one competency may be needed to achieve other(s), each competency is individually distinct from the others. Table 1 provides the working definitions of each competency, redefined based on the authors’ interpretation.

Table 1: KOM Competencies and Definitions

Competency	**Definition**
Mathematical Thinking	Ability to understand the structure of math questions and answers, the scope of mathematical problems, and generalize results
Problem Tackling	Ability to distinguish between different types of math problems, and solve those math problems based on their distinction
Modeling	Ability to analyze, interpret, and create mathematical models both within mathematical fields and in outside areas
Reasoning	Ability to follow informal and formal mathematical reasoning and make arguments using that reasoning - arguments can be formal, such as proofs, or can be constructed using intuition and heuristics
Representing	Ability to understand and utilize different representations of mathematical entities while understanding the strengths and weakness of each
Symbol and Formalism	Ability to understand mathematical symbol language and decode information between symbols and plain speech
Communication	Ability to communicate mathematical concepts and understand others communication to different layers of technical precision
Aids and Tools	Knowledge of the various mathematical tools available to them, understanding their limitations, ability to use said tools

The KOM competencies framework was chosen as a conceptual guide for this work due to its prior use in engineering education. For example, Alpers et al. adapted this framework to suggest guidelines for developing mathematical curricula in different engineering programs [12]. Tague et al. used this framework to study faculty perceptions engineering students’ math readiness. Faulkner and colleagues explored faculty perceptions on what constitutes mathematical maturity for engineering students [5], [6].

3. Methods

3.1 Research sites

This study is being conducted at two universities: one private R2 and one public M1 university (based on Carnegie Classification), both located in the mid-Atlantic region of the USA. The private R2 university (referred to as “Large Private University” in the paper) offers, through different colleges, undergraduate degrees in both engineering and engineering technology. The university has admitted 650-750 incoming first-year students in engineering and 350-500 in engineering technology over the last few years. The public M1 university (referred to as “Medium Public University” in the paper) offers undergraduate degrees in engineering. During recent years, it has admitted 650-750 incoming first-year engineering students. Both universities offer degrees in a range of engineering disciplines including biomedical, chemical, civil, computer, electrical, engineering science, industrial, and mechanical.

3.2 Data collection

As the goal of this study is to explore faculty perception of engineering students’ math readiness, all engineering (including engineering technology) faculty members teaching undergraduate courses at the research sites formed the potential participant pool. They were emailed explaining the purpose of the study and inviting them to participate. All who expressed interest in participating were recruited. IRB approval was obtained before emailing the participants.

Data were collected in the form of semi-structured interviews. The interview protocol probed the participants to reflect on the mathematical concepts used in the engineering courses taught by them, the readiness of students to apply these concepts, and how they respond to students’ math readiness. They were also asked for general recommendations on improving students’ math readiness. These interviews were conducted by the first author. As of writing this paper, we have completed 20 interviews across the two research sites.

This paper presents an analysis of the initial seven interviews. These seven interviews are drawn from both universities and represent participant diversity in terms of race, gender, nationality, engineering discipline, and course level. Table 2 summarizes participants’ demographic details, engineering disciplines, and the levels of courses taught by them. Note that for this paper, we do not distinguish between engineering and engineering technology degrees. This is because both offer an engineering pathway to students. We acknowledge that there may be differences in faculty’s expectations of and responses to students’ math readiness in these disciplines; however, we did not analyze data along disciplinary lines.

Table 2: Participant Demographics

Gender	5 male, 2 female
Race	3 Asian, 1 African American, 3 Caucasian
Nationality	3 US Citizens, 2 Dual citizens including the USA, 2 International
Engineering Discipline	4 Civil Engineering, 3 Mechanical Engineering
Course Level Taught	3 First Year, 3 Third Year, 1 Fourth Year

3.3 Data analysis

Interviews were transcribed using otter.ai™ and checked for accuracy by the first author. Following this, data were thematically coded using the conceptual framework of KOM competencies as the starting point to identify faculty perceptions of students’ math readiness and the corresponding responses. However, as the data analysis progressed, we found that the math-related issues identified by participants did not neatly align with the KOM competencies; rather they often overlapped across different competencies. Hence, the final codes were generated inductively to more accurately represent the data. These codes were then categorized into themes. Coding was primarily performed by the first author with regular discussions with the second author on the credibility of the codes and themes generated. The final themes are discussed in the next section.

4. Findings

This section describes the findings from data analysis in response to the two research questions. Example quotes are provided within each theme. Participants are identified with pseudonyms.

4.1. Faculty perceptions of students' math readiness

Our analysis suggests that there are two major issues regarding students' math readiness, as stated by the participants. The first relates to students' ability to understand math concepts and perform computation. The second pertains to students' ability to apply math concepts in the context of engineering applications. Additionally, faculty identified potential causes that lead to these issues. The following sections discuss them in detail. It should be noted that not all students struggle with math-related issues, as explicitly highlighted by some participants. The goal of this paper is to describe the nature of students' struggles, not the ubiquity.

4.1.1 Issues with mathematical concepts and computations

Throughout the process of analyzing interviews, a recurrent theme that emerged was faculty perception regarding students' inability to understand the meaning of different math concepts and perform computations using them. Participants attributed various reasons to this issue including concerns related to memory, procedural knowledge, understanding, and representation of mathematical ideas.

Memory related issues encompass students' struggle to remember mathematical concepts that they had learned previously in the same or a different course. For example, as noted by Ming, a mechanical engineering professor at Medium Public University:

> *I tried several times without formula sheets, and the students [felt] nervous. Then, they cannot do well and they need to have a formula sheet next to them [so] that they feel comfortable. I think this needs to be this need to be changed.*

In this quote, Ming highlights that her students have little memory of formulas that they use throughout the course and expresses that this issue needs to be addressed. Several times during the interview, Ming stated that students often do not remember math concepts they learn in the course.

Linked with memory-related issues, faculty members also highlighted that students struggle with mathematical procedures, such as knowing how to compute derivatives or integrals, or solve algebraic equations. As stated by Logesh from the Large Private University:

> *Well, like I said, manipulating, manipulating equations, you know, so separating the known from the unknown, right? So there is a way that you can move variables around such that the unknown is on the left hand side of the equality sign, and all the known factors are on the on the right hand side of the equality sign, they don't present themselves in the simplified form. So if you need to simplify an equation for more efficient calculation, then that is something they struggle with.*

Logesh's comment highlights his perception that students do not have a mastery of performing basic algebraic manipulations, which is a necessary skill for advanced calculations and develop conceptual understanding.

Beyond memory and procedural knowledge, several participants noted students' struggles with basic mathematical concepts. These issues include both conceptually understanding mathematical ideas and making meaning of the symbols and representations used in mathematics. For example, a participant from the Large Private University, Leonard, stated that his students struggle to both understand the meaning of integration as a mathematical concept.

> *The hard part is reading the math and being able to interpret it, right? Like, what does an integral mean?... Is it the sum of the area under the curve? Is it? Are we talking about a sum of changes? What are we talking about, right? What is that symbol mean to you?... If I were to give someone a math equation, say, write this down as a sentence. Could you do that? And that's the first stumbling block, as students see it.*

This comment by Leonard highlights that while students may have the procedural knowledge to perform mathematical computations, they do not have the conceptual understanding of various mathematical operations. Leonard further elaborated on students' struggles with mathematical representations by noting how his students struggle while moving between different representations:

> *So, you know, you have your three equations, three unknowns, or four equations, four unknowns, and now you have to plug everything into systems and equations, and students feel okay with that, right?... So algebra is the comfort zone. As soon as you go, "Okay, so let me just give you just the basic rules of this thing called a matrix. You just arrange your equation like this, you put it in like this, and you press solve, and out comes your answers." Terror! Abstract terror!*

This comment shows students' lack of conceptual understanding of different mathematical operations. This is probably why they find it difficult to move from algebraic to matrix notation while solving a system of linear equations.

Overall, all participants perceived that their students experience challenges with different aspects of mathematical concepts and computations, whether it is recalling math concepts, knowing how to do common mathematical computations, understanding what mathematical concepts mean, or moving between math-related representations.

4.1.2 Issues in applications of math concepts

Another significant pattern that emerged in faculty perceptions was students' struggle in applying their mathematics knowledge. These struggles relate to difficulties in applying mathematical knowledge to engineering problems, challenges with interpolation and handling uncertainty, and struggles with moving between engineering-related representations of mathematical objects.

Even when students can perform mathematical computations, they struggle with aspects of problem solving that are specifically related to applying the concepts in an engineering course. As stated by Mahsa from the Medium Public University:

> *I think the students knew what the partials [differential equations] mean. But when it came to actually solve the equations, which turned into a simple PDE and turned into a Math 1 stuff, they had issues with the concepts of boundary conditions. They had issues with the concepts of integrating an equation and then finding the constants in that integration.*

In this example, the boundary conditions Mahsa notes stem from course-specific contexts, and his students face difficulties in applying these boundary conditions for performing integration and thus solving the given problem.

Participants also highlighted difficulties students experience using math concepts in situations that require extrapolation or navigating engineering design-related uncertainties. As stated by Matthew from the Medium Public University:

> *When you take math courses, there's a definitive answer. And they look for a definitive answer. But again, back to transportation I, when it's a design course, you have to account for a whole bunch of different things, different types of vehicles, different types of road conditions, different types of human behavior. And so there's so many variables that you cannot get an exact answer. And so you have to get a range or get an idea of what that answer is going to be.*

Highlighting students' inclination to arrive at the correct answer, Matthew further added that students also struggle with the iterative aspect of engineering design when they must estimate a range of possible values and run analysis to check whether their estimation is appropriate. Students' tendency to look for a definitive answer highlights a gap in students' learning of math and how mathematical knowledge is applied in engineering domains. They tend to think of mathematical applications to give definitive answers (probably because of how they learned math). However, most engineering applications of math rely on estimations and extrapolations involving uncertainties.

Lastly, similarly to students' issues with mathematical representations, faculty perceived that students have difficulty representing mathematical ideas using symbols and visuals used in engineering. For example:

> *What you find is that if you take a student and you say, "Okay, go look at a spectrogram", it's a plot. You know how to read a plot, frequency down here, amplitude, here, right? They go, "Okay, I can read that plot". If you give them data and you say, "Okay, make a plot out of this data", they kind of would look at you and go, "Well, I don't, I don't understand, right? Like, what is, what does any of that have to do with anything? What does sampling have to do with anything? What does Nyquist frequency have to do with anything?" (Leonard, Large Private University)*

This comment by Leonard suggests that while students can comprehend mathematical representations, they are still unable to apply their learning to create representations used in specific engineering applications.

Overall, faculty perceived that students lack the skills to apply math concepts to their engineering courses, struggle with estimations and uncertainties in engineering problem solving, and find it difficult to create mathematical representations used in engineering. While students can work with certain math concepts and have a degree of procedural knowledge, they still encounter challenges with course-specific applications using that knowledge.

4.1.3 Time gap between math and engineering courses

Some participants highlighted a significant time gap between when students learn math concepts in a math course and when they are expected to use them in an engineering course. This gap often leads to students having memory-related issues regarding mathematical concepts and procedures. For example, Ming noted the time gap between when her students take linear algebra and when it is used in her course:

> *They learn them in sophomore [year], then there is no other process. So I expect them to forget about certain concepts.*

As can be seen from her response, she expects students to forget some of the concepts from math courses by the time they take her course. Similarly, talking about his students' math struggles, Matthew recounted:

> *And we get to that point where I'm looking at juniors and seniors at this point. And so the calculus is kind of, usually like a year out or two years out.*

It should be noted that usually calculus courses are taught in the first two years of an engineering degree. However, several of these calculus concepts are applied in upper-level engineering courses. Since students do not get an opportunity to regularly practice these calculus concepts, they often forget them by the time they must apply them in an engineering context.

4.1.4 Lack of integration between math and engineering courses

Another common cause that participants attributed to students' struggles with math concepts, especially their ability to apply the concepts in engineering problem solving, is the perception that math and engineering are not well integrated. This was often expressed during the interview in the form of a desire to integrate engineering problems into math courses or a desire to have more application-based math courses. For example, Logesh from the Large Private University stated:

> *So if I had my druthers, if I was to teach a math course... I would [focus] on application, which a student can relate to because the student is interested… in pursuing a certain profession, whether it's electrical engineering, mechanical, civil it doesn't matter. And if they find that the math course they're in relates to their profession, then they're more curious about it.*

However, though participants often desired the integration of math and engineering, this solution is not very easy to apply given the curricular structuring of the degrees and how academic colleges and departments operate within a university. Hence, participants noted adopting different strategies to help students apply math concepts in engineering courses. These strategies are discussed in the next section.

4.2 Faculty response to students' math readiness

The approaches that participants implement to address students' difficulties with math concepts and their application in engineering include use of class time, providing support outside of class, encouraging students to learn from one another, and avoiding advanced use of math in their courses. These approaches are discussed below.

4.2.1 Use of class time

The use of class time is a primary strategy that the participants adopt to help students either with math concepts and computations or their application in engineering. The utilization of class time takes different forms depending on the issues that students face. When students struggle with remembering math concepts, procedures, or representations, faculty use regular class time to review the relevant content. For example:

> *So, just review part is important. But as I mentioned, they learn the fundamental concepts from the maths courses, why do the review? [It] is much easier… the concepts they just forgot certain rules, but so, I don't need to spend the time to introduce the matrix, the size, the array, I need just recall the rules that they practice. (Ming, Medium Public University)*

> *And when we introduced MATLAB, we started talking about loops. And I'm like, "All right, well, you know, let's, let's start with an equation for a line, maybe a straight line, maybe a curve, whatever. And let's start finding like areas under those curves." And then we'll just in a loop, add up those areas. And you know, you kind of get them through this*

programmatic experience. You say, "Okay, anybody know what we just did?" And then you get the one kid in the back of the class, right, who's had like, college level math in high school that just sheepishly raises their hand and goes, "Did we just integrate that?" (Leonard, Large Private University)

In the first quote, Ming describes how she reviews in class the rules of matrix computations as the students may have forgotten the procedural aspects of it. In the second quote, Leonard describes how he combines a math concept (integration) with MATLAB learning (loops) for students, thus helping students to get a better grasp on the math concept.

Participants also noted sometimes highlighting similar math concepts that students have used in an earlier course to help them make the connection and apply these concepts in the current course. For example:

I asked the class at large, "Hey, can someone give me an example of what an Eigenvalue/Eigenvector vector is?", and no one had an answer for it…. So I started to draw their attention to the courses that they were taking at the same time… And most of the class were taking strength of materials. And then I started saying that, "Hey, for example, the principle stresses that you are learning in that class, those are eigenvalues. So, and then eigenvectors are those principal axes that you find over which a part breaks." (Masha, Medium Public University)

Thus, by helping students recall the application of math concepts in a previous course, Masha addresses some of the application-related math struggles that students face in his course.

4.2.2 Providing support out of class

In addition to reviewing concepts and making connections to students' prior learning, faculty also provide students with support outside the class. This support comes in the form of working with students during office hours, directing them to university resources such as the tutoring centers, or use of assignments. For example, Lebechi from the Large Private University recounted working with students during office hours to help them with math issues:

I have a whiteboard in my office. So I draw on the board, draw on a piece of paper, ask them to repeat the process. "Okay, let's go through this example again." So I walk through the example with them. And I have them walk through a similar kind of example, just to be sure that they understand it.

She further added that she also encourages students to make use of the tutoring services offered by the college:

[O]ne of the things that I do in classes announce like talk to them about tutoring services and make sure you use the teacher services available on campus. "These people are students as well, they have taken some of the courses you take in, they understand the struggles, they'll be able to explain things to you."

Besides providing support to students in and out of class, participants also noted giving assignments that help students catch up with the math concepts they are struggling with. These homework assignments help students practice some math procedures and computations that they might have forgotten.

4.2.3 Encouraging peer learning

Faculty utilization of peer learning takes the form of encouraging students to work together on solving problems or learning mathematical procedures. As one participant noted asking students who are exceling in the course to collaborate with those who are struggling:

> *I do and I think the other faculty also does the same thing that we use those very good group of students who are very well versed about the topics we are teaching, use them in that recitation class, work with that little bit falling behind students one-on-one. (Lakesh, Large Private University)*

Lakesh emphasizes that this approach helps students who are behind to catch up. It should be noted that this method is particularly helpful for students because those who are novices with the course material are, at times, able to better explain concepts to other novices as compared to faculty who are experts.

4.2.4 Avoiding advanced use of math

Some participants also noted modifying their instruction in a way that avoids using advanced math. This approach prevents students from encountering math concepts that participants believe they will struggle with. For example:

> *I would typically tell them that "okay, even if you don't understand how the equation is coming out, you know how to use the equation, and that is [what] we are more concerned with." (Lakesh, Large Private University)*

Lakesh further added that he adopts this strategy because students require an understanding of underlying math concepts to be able to completely understand how the equations are derived. He believes that students do not always have this understanding. Hence, he adopts this strategy so that they do not fall behind in the course by spending time in learning the background math.

4.3 Summary of the findings

Figure 1 presents the summary of the findings. The left half of the diagram lists issues related to students' math readiness that the participants highlighted. The right half notes the approaches that they adopt to respond to these issues. The arrows from the issues to the responses denote the approaches participants adopt to address the issues.

In terms of issues, participants perceived that students are not able to adequately understand mathematical concepts and struggle to perform mathematical computations. When students are competent in these areas, they struggle with applying math concepts in engineering problem solving. Participants also highlighted potential causes for these issues, as shown by the broken arrows in Figure 1. They noted that the time gap between introductory math and engineering courses leads students to forget math concepts by the time they take engineering courses. Also, since math courses are not integrated with engineering applications, students often struggle to apply math concepts in engineering.

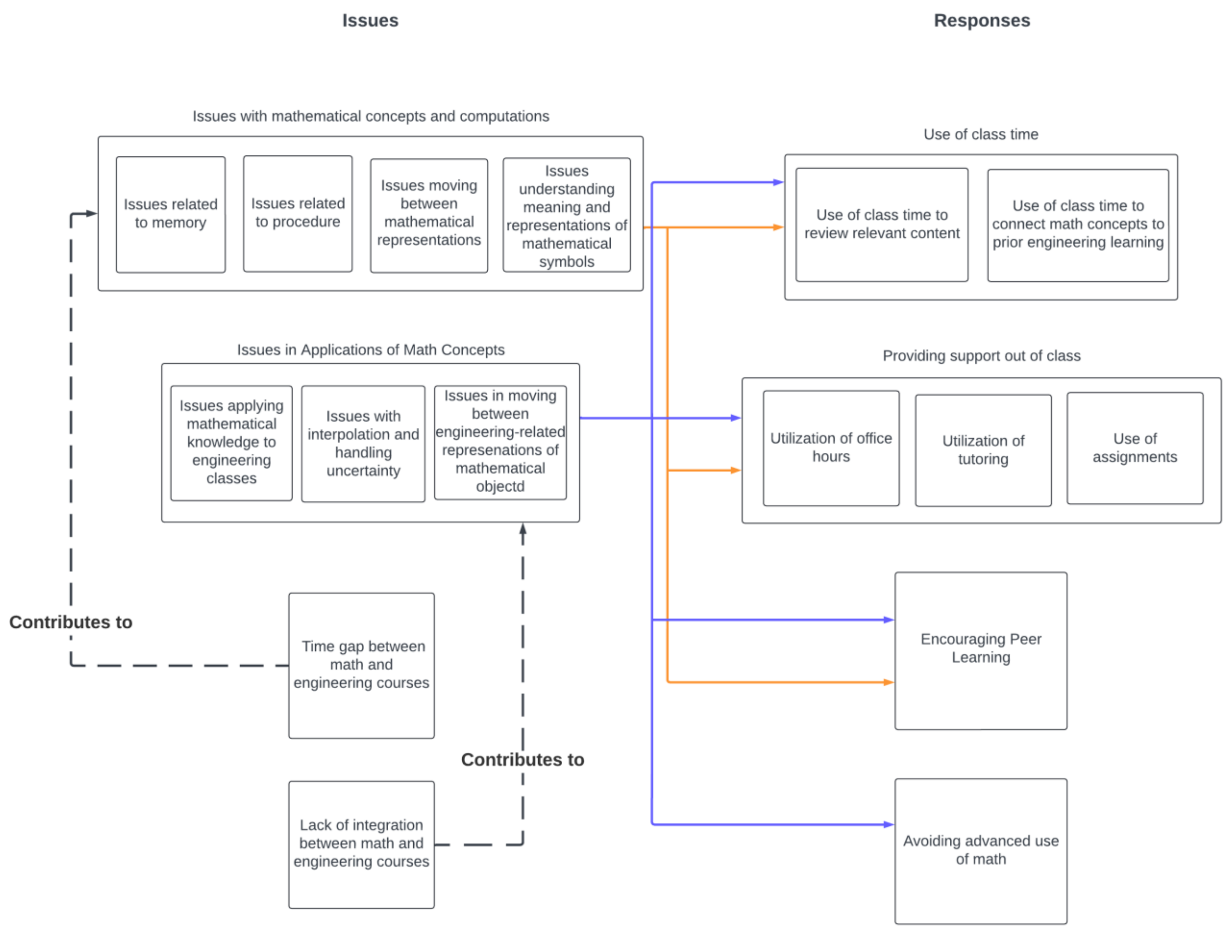

Figure 1: Faculty perception of and responses to students' math readiness

Faculty generally respond to students' math struggles by spending class time reviewing math concepts and highlighting engineering applications of these concepts. Additionally, they support students' learning through out-of-class resources such as office hours, directing them to tutoring services, and giving them assignments to practice math concepts. Moreover, they encourage peer learning among students. Some participants also noted that they avoid the use of advanced math concepts in their courses to minimize student struggles.

5. Discussion and Conclusion

Although the findings presented in this paper are based on the analysis of a small number of faculty interviews, they point to some key aspects of students' math readiness. First, reinforcing the finding from prior studies [3], [4], [5], [6], engineering faculty in this study perceived that students struggle with both understanding math concepts and applying them in the context of engineering. Additionally, participants also highlighted the need for better integrating math and engineering courses. Conversations about this integration are not new [8]; however as prior studies have noted this initiative requires significant institutional effort [9]. Nevertheless, it remains an issue that needs to be addressed by engineering colleges and departments.

One key contribution of this study is connecting faculty experiences of students' math readiness to the strategies they adopt in their engineering courses. While prior studies have highlighted faculty experiences as they related to students' math readiness, our work juxtaposes faculty experiences with navigational strategies they implement. A salient finding is that faculty use class time to help students learn math concepts and their application in engineering problem solving. While this approach addresses the immediate issue, it needs to be further investigated to determine whether this comes at the expense of the class time that could have been used to help students more deeply learn engineering concepts.

Our findings also suggest that some faculty avoid using advanced math concepts in their engineering classes. While this is done to ensure that students do not fall behind in the course, this strategy may prevent students from experiencing how math and engineering are integrated. The application of math to solve engineering problems is a key learning outcome of all ABET-accredited engineering and engineering technology programs [13], [14]. Caution must be exercised to ensure that avoiding advanced math does not prevent students from achieving this outcome. Also, care must be taken to ensure that this approach does not prevent students from developing mathematical maturity, something that previous research has highlighted as lacking in engineering students [10].

In conclusion, our findings, although exploratory in nature, reiterate the call for a better integration of math and engineering courses. Additionally, we recommend that engineering faculty should be provided with adequate resources that they can use in their courses or pass on to students to support their math skills in the context of engineering problem solving.

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References

[1] P. Winkelman, "Perceptions of mathematics in engineering," *Eur. J. Eng. Educ.*, vol. 34, no. 4, pp. 305–316, Aug. 2009, doi: 10.1080/03043790902987378.

[2] I. Biza, A. S. Gonzalez-Martin, and A. Pinto, "'Scaffolding' or 'Filtering': A Review of Studies on the Diverse Roles of Calculus Courses for Students, Professionals and Teachers," *Int. J. Res. Undergrad. Math. Educ.*, vol. 8, pp. 389–418, Jun. 2022.

[3] G. Nortvedt and A. Siqveland, "Are beginning calculus and engineering students adequately prepared for higher education? An assessment of students' basic mathematical knowledge.," *Int. J. Math. Educ. Sci. Technol.*, vol. 50, no. 3, pp. 325–343, 2018.

[4] K. Aung, R. Underdown, and Q. Qian, “Vertical assessment of math competency among freshmen and sophomore engineering students,” presented at the 120th Annual ASEE Conference and Exposition, Atlanta, Georgia: American Society for Engineering Education, Jun. 2013.

[5] J. Tague, J. Czocher, G. Baker, and K. Harper, “Engineering Faculty Perspectives on Mathematical Preparation of Students,” Jul. 2013.

[6] B. Faulkner, G. Herman, and K. Earl, “Engineering Faculty Perspectives on Student Mathematical Maturity,” American Society of Engineering Education, 2017.

[7] F. Ronning, “The Role of Fourier Series in Mathematics and in Signal Theory,” *Int. J. Res. Undergrad. Math. Educ.*, vol. 7, pp. 189–210, Jun. 2021.

[8] L. Katz, M. D. Graham, D. Bigio, and B. Oni, *The Curriculum Foundations Project: Voices of the Partner Disciplines: Reports from a series of disciplinary workshops organized by the Curriculum Renewal Across the First Two Years (CRAFTY) subcommittee of the Committee for the Undergraduate Program in Mathematics (CUPM)*. The Mathematical Association of America, 2004.

[9] B. Ellis, S. Larsen, M. Voigt, and K. Vroom, “Where Calculus and Engineering Converge: an Analysis of Curricular Change in Calculus for Engineers,” *Int. J. Res. Undergrad. Math. Educ.*, no. 7, pp. 379–399, 2021.

[10] B. Faulkner, K. Earl, and G. Herman, “Mathematical Maturity for Engineering Students,” vol. 5, pp. 87–128, 2019.

[11] M. A. Niss and T. Højgaard, *Competencies and Mathematical Learning Ideas and inspiration for the development of mathematics teaching and learning in Denmark*. Roskilde University, 2011.

[12] B. Alpers *et al.*, “A framework for mathematics curricula in engineering education: A report of the mathematics working group,” Brussels: European Society for Engineering Education, 2013.

[13] “2023-2024 Criteria for Accrediting Engineering Programs.” ABET Engineering Accreditation Commission, 2022.

[14] “2023-2024 Criteria for Accrediting Engineering Technology Programs.” ABET Engineering Technology Accreditation Commission, 2022.