Challenges in Engineering Statics: Students' Perceptions of Their Difficulties

Mrs. Ibukunoluwa Eunice Salami, University of Nebraska - Lincoln

Ibukunoluwa Eunice Salami is a third-year PhD Candidate in Engineering Education Research at the University of Nebraska-Lincoln. Her research interests include competency development, graduate education, the transfer of learning, school to work transition for engineering students, use of technology in engineering education, students retention in engineering programs and motivation of students in engineering education.

Dr. Logan Andrew Perry, University of Nebraska - Lincoln

Dr. Perry is an Assistant Professor of Engineering Education in the Department of Civil & Environmental Engineering at the University of Nebraska-Lincoln. His work contains a unique blend of engineering education and civil engineering projects. Dr. Perry's current work centers workplace readiness, broadening participation, and construction safety education.

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Abstract

Engineering statics is a foundational course for engineering students, serving as a prerequisite for advanced courses such as mechanics of materials and playing a critical role in determining student retention in engineering programs. However, an analysis from a Midwestern university revealed that an average of 11.4% of students across all courses received D, F, or W grades as compared to 26.9% D, F, W rates in engineering statics, highlighting statics as a challenging course for students. A previous study explored instructors' perspectives on the high rate of D, F and W grade in engineering statics, themes such as “difficulty in introducing practical applications, large class sizes, weak foundations in prerequisites, inconsistent use of resources, and insufficient attention to detail” highlighted the reasons why instructors perceive students’ perform poorly in engineering statics.

This paper is a follow up to that study and a deep dive into what students describe as challenging in an engineering statics course. The research questions answered in this study is: What do students perceive as challenging in an engineering statics course?

Data was collected from seven students enrolled in the course during the Spring and Fall 2024 semester. The data was analyzed using thematic analysis to generate themes that address the research questions. The findings from this study aim to inform teaching strategies and interventions that directly target the most challenging aspects of engineering statics as described by the students themselves.

Introduction and Background of the Study

Statics is defined as “the study of distribution and effect of forces on rigid bodies which are at rest and remain at rest” [1, p. 1]. Statics is a core pre-requisite course for subsequent engineering courses such as dynamics and mechanics of materials, the combination of which is a critical part of the engineering curriculum [2]. Simply put, an understanding of statics is crucial for success in more advanced engineering courses. However, prior research highlights that engineering statics can be particularly challenging for students and can hinder their progress toward graduation [3], [4], [5]. Students with low grades often have to retake the course, which has direct impacts on retention in engineering programs [6].

Prior research examined instructors' perceptions of the high rates of D, F, and W grades in an engineering statics course at an R1 Midwestern University [7]. Instructors identified several challenges contributing to these outcomes, including students' weak foundational knowledge in prerequisite subjects, lack of attention to detail, and inconsistent use of available resources. This follow-up study aims to explore challenges from the students’ perspective. By identifying areas of alignment and divergence, this study seeks to provide actionable insights for addressing learning gaps and improving teaching strategies in engineering statics. The study answers the research question: *What do students describe as challenging in an engineering statics course?*

Data for this study were collected through semi-structured interviews conducted over two semesters (Spring and Fall 2024) with seven engineering statics students. The findings have

potential to offer valuable guidance for enhancing student learning, improving academic performance, and increasing retention in engineering programs.

Challenges in Engineering Statics

Engineering statics is often referred to as a "gate-keeper course" [8]. Engineering statics presents significant challenges for students due to the complexity of topics, such as vector operations, free-body diagrams, moments, reactive forces, the behavior of various supports, and force analysis in trusses, frames, and machines, which require considerable effort to master [9], [10]. Numerous studies have proposed and implemented various strategies to enhance student success on this subject, including the use of mechanical breadboards [10] diverse teaching styles [11], hands-on design projects [12], sketching tools in SolidWorks [13], numerical modeling techniques [14], animated GIFs [15], task-analysis-guided deliberate practice [16], the explored view approach [17], and inquiry-based learning methods [18]. Still, high DFW rates remain.

To effectively tackle the complex topics in engineering statics, students must develop a strong understanding of the fundamental concepts and techniques. One of the most crucial skills in mastering statics is the ability to create accurate free-body diagrams [8], as they serve as the foundation for solving a wide range of problems in the subject. While textbooks provide detailed instructions on constructing various types of free-body diagrams, some students still struggle to draw them correctly for their specific problems [7], [8]. Other issues noted as prevalent in the course include: weak foundations in prerequisites such as math and physics [7]; visualizing or conceptualizing forces [2], [19]; the concatenation of influences, especially in cases where students' need to determine the net effect of a combination of forces; and challenges with teaching style and course schedule [6], [20].

Our previous study thoroughly explored the literature on engineering statics, the difficulties students encounter, and interventions in teaching statics [7]. This follow-up research complements our previous findings by focusing specifically on how students describe their struggles in mastering engineering statics. While prior studies have identified common issues such as challenges with forces and moments, weak mathematics skills, and difficulties visualizing forces [2], [19], there has been limited focus on how students articulate these struggles in their own words [21]. This study provides a deeper insight into students' personal experiences and perceptions. By centering their views, this research aims to inform teaching strategies and interventions that address the most pressing challenges in engineering statics as described directly by students.

Methodology

Methods

Participants & Settings

The participants in this study included seven undergraduate students enrolled in a statics course during the spring and Fall 2024 semester at an R1 midwestern University in the United States. These students were recruited from four sections of statics course across one academic year. They were self-selected through their involvement in an undergraduate mentoring program for engineering statics. The participants included both high-achieving students and students facing

difficulties in the course, ensuring a diverse representation of academic performance. The statics course is offered twice a week, with each class period running for 75 minutes and taught by one of two faculty. Students are encouraged to take advantage of weekly office hours to discuss their difficulties with the instructor. The class also hosts a required weekly recitation session.

Data Collection

The researchers adopted the use of semi-structured qualitative interviews as the data collection mechanism. IRB processes were followed, and transcripts were de-identified to ensure data anonymity. Data and information of participants were saved to a secure One-Drive folder with access restricted to the principal investigators only. Some of the interview questions relevant to this study that students were asked included:

- Describe your experience with the statics course. What is going on well? What is not? How many times have you taken statics?
- I'm going to share my screen with a list of concepts that are covered in statics. Are there particular concepts that you are struggling with? Describe them. What is making those concepts challenging?
- How did you study for statics exams/quizzes? How much time did you spend? Did you study alone or with friends? What study techniques seemed to be most effective?

Data Analysis

Transcripts were analyzed using thematic analysis [22] and resulted in four themes that provide a rich description of student perceptions. The responses were deidentified and coded by the authors to ensure reliability and establish trustworthiness. We took an inductive approach for data analysis as the codes and themes were developed to showcase the participants' perspectives based on their experiences with engineering statics.

Reflexivity

The authors of this paper are engineering education researchers. Author 1, an African with experience in complex engineering courses, is particularly interested in researching how difficult courses impact student success and engineering careers. Author 2, a white engineering faculty from the United States, struggled with statics during his own undergraduate career. Both authors acknowledge that their biases and experiences could influence their interpretation of the participants' responses. To address this, they employed the method of bracketing by writing down their experiences and consciously focusing their interpretations on those of the participants. They also discussed their interpretations of the findings on multiple occasions to ensure the integrity of their coding [23].

Findings

Based on the experiences of undergraduate engineering students enrolled in the statics course at a midwestern R1 University, four themes (which are further divided into sub-themes) were developed, which capture students' experiences on the challenges they experience with the course.

Theme 1: Building on Foundational Knowledge (Applying Prerequisites)

This theme refers to the difficulties and challenges students face when attempting to expand upon the fundamental concepts they learned in previous courses as they engage with more advanced material in statics. Engineering statics typically requires prerequisites such as physics (mechanics), calculus, and trigonometry, as these subjects provide essential mathematical and conceptual tools for analyzing forces, moments, and equilibrium. However, students in this study expressed difficulty in connecting concepts from these prerequisite courses to the material being taught in statics. Students struggled with effectively applying mathematical techniques, such as solving equations or using prior problem-solving methods, in a new context. The data also highlighted confusion arising from different methods or approaches introduced in earlier courses (e.g., centroid calculations in Calculus 2 versus statics), which hindered clarity and made it difficult to master new concepts. While some prerequisite knowledge such as trigonometry and physics concepts is occasionally revisited in statics, students reported that these reviews were often brief or assumed prior mastery, making it challenging for those with weaker backgrounds to keep up. Participants explained:

> *"Last semester I took physics and I'm not too great at understanding physics, so that's been kind of a struggle. Like right now we're in the friction portion of the course. So that's kind of been hard to grasp. ...So more than anything, kind of the more basic physics aspect of it, I do understand scalar and triple products, moment about a force, about an axis. I do understand that. I would probably struggle with doing a problem with it, but I understand the concept."; Participant A*

> *"I learned centroids in a different way, and the way that they are taught in this class are a little confusing for me. I learned them in Calc 2, and they are different from Calc 2." Participant C*

The above excerpts revealed that understanding and successfully completing problems in engineering statics is dependent on a strong foundational background in physics. The transcript also reveals that the concept of centroids is taught in both statics and in Calculus 2. However, the two concepts are taught in different styles and applying the knowledge from Calculus 2 to engineering statics is different, which can cause a bit of challenge and confusion for the students. A similar quote on the application of prerequisites also discusses the importance of trigonometry before enrolling in engineering statics:

> *"I did not take trigonometry, and a lot of the questions revolve around, you know, doing trigonometry, knowing your trusses and just from my experience itself, I failed to understand that because I haven't taken it before." Participant F*

The quotes above reveal that students attributed some of the challenges they experience in engineering statics to their understanding and their ability to apply knowledge from prerequisites subjects such as physics, centroids and trigonometry.

Theme 2: Course Difficulty and Concept Mastery

This theme reflects students' initial perceptions of the difficulty of the course and the challenges they encounter in mastering key statics concepts. The theme emphasizes both external

perceptions and internal struggles in learning the contents of the course. The theme was further divided into two sub-themes: "*Preconceived Notion of Hardness*" and "*Understanding and Applying Key Statics Concepts*".

Preconceived Notion of Difficulty

This subtheme is defined as students' initial beliefs about the difficulty of the statics course before their learning experience. These beliefs are influenced by hearsay and the course's reputation, shaping students' perceptions of the challenges and external pressures associated with studying engineering statics. An example of such is:

> *"I think I was very concerned taking it, because I heard it was always really difficult. I think it's just a hard class." Participant A*

Participant A revealed that they came into the class with the preconceived notion of the class being difficult. Another participant reinforced the belief that their current struggles are tied to their enrollment in statics and it being difficult compared to the other courses they were enrolled in:

> *"I had heard from upperclassmen that this statics is just a difficult class. Right now, I am taking statics, and so far I feel like I have been struggling just quite a bit, and I feel like this is just a very hard class in general compared to other previous classes I've had before." Participant F*

Participant F further revealed that:

> *"I think it's very difficult. I think the course in general, like I said, like statics, is very difficult in general, like nobody can just come in and just do all the work without taking the time, having patience to do the problems. And each problem kind of takes, you know, a long time. Some problems take at least like an hour and just try to figure it out, and especially when it comes to trigonometry or anything like that. But it is a difficult class"*

In sum, students' perceptions of difficulty often begin before the start of the semester, further compounding the difficulties they experience during the course itself.

Understanding and Applying Key Statics Concepts

This subtheme refers to the challenges students face in grasping and applying fundamental principles and techniques in statics, which are crucial for problem-solving. The structure of the statics course typically adopts traditional lectures format. However, the pace of content delivery can be rapid, requiring students to quickly transition between topics without sufficient time to fully absorb fundamental principles before advancing to more complex applications. Additionally, while lectures introduce problem-solving methods, students often find that the depth of explanation or the examples provided may not always align with their learning needs, making it difficult to translate theoretical knowledge into practice.

These difficulties include struggling with complex topics like centroids, particularly when calculated by integration, and understanding how to apply various formulas or set up problems

correctly. Students also reported that they found it challenging to break down complex structures (e.g., frames, machines, composite bodies, trusses) into simpler components, such as free body diagrams, and to determine the correct methods for analyzing forces, such as reduction of forces and methods of sections. Additionally, concepts involving 3-force bodies, moments of force, and the integration of various mathematical techniques (e.g., polar coordinates, double integration) add further complexities as students often face difficulties in translating theoretical knowledge into practical applications. Overall, these challenges reflect the need for deeper mastery of key concepts. Participant A shared their experience:

> *"So, I want to say from frames and machines to belt friction is what I don't really understand, what I need to read up on. Things started getting a little bit harder during moment of force. And then centroids kind of mess with me. I'm still not too good at them. I still need to focus on centroids. I get kind of tripped up on setting them up and I never kind of know which formula to use. Like in the exam, I completely forgot how to use the formulas or like what was the correct formula to use? And right now we're doing trusses and frames, so I understand how to find zero force members in theory, but when I do it on a problem it gets a little tougher." Participant A*

Participant B highlighted the difficulties they encountered when applying their understanding of the course to solve statics problems:

> *"Yeah, I know the one that's really giving me problems is the integration one, so like, the centroid by integration ones. I think those are really difficult. I understand what we're trying to find, like, we're trying to find the center point in either an area under the curve or in a 3 dimensional object. But it doesn't click with me how to find it, like how to set up the problem. It just doesn't click." Participant B*

Participant C expressed that the complexity of composite bodies contributed to their confusion and hindered their understanding of concepts:

> *"The 3 force bodies sometimes are a little confusing for me. Same with the composite body. I just think that it has too many components that I just can't wrap my head around. And I just don't know how to correlate them to each other, like sometimes I'll just repeat the same thing, and I don't know where things come from. If that makes sense. Also, centroids of a composite body I struggle with. I don't think I really got the hang of those either."*

Participant E explained that they initially found the concept of force reduction straightforward during lectures and homework, leading them to overlook fully mastering it. However, when preparing for the exam, they realized their understanding was incomplete, and the topic proved to be more complex than they had initially perceived:

> *"I'd say I'm struggling on reduction of forces, because it was one of those things where I kinda I looked at it in lecture, and then I did some of the homework problems. And I said, oh, this is simple, and then I kind of just you know, didn't really bother to master it that much because I felt I understood it. And I actually studied that before the exam last week. During the exam, that's when I realized, wait a minute. I don't actually know how to do this, and it can get kind of complicated." Participant E*

Participant G's quote reflects their struggle with applying fundamental concepts like breaking down complex structures into smaller, manageable parts (free-body diagrams). The challenge lies in grasping the process of dividing structures, such as trusses and frames, correctly to apply the method of sections.

> *"I think pretty much the topics where it requires you to like break it down into like smaller free body diagrams. I get confused with like where you're supposed to divide it up." Participant G*

These quotes highlight the difficulty students face in understanding how to use these essential statics concepts effectively to solve problems.

The theme course difficulty and concept mastery, as revealed in the transcripts, highlights that while students may grasp certain concepts in engineering statics, their preconceived notions about the course's difficulty and the challenges they encounter when applying their understanding to solve statics problems significantly impact their learning experience.

Theme 3: Workload and Schedule Strain

This theme refers to the challenges students face in managing their academic responsibilities within the constraints of a demanding statics course. This theme was subdivided into two sub-themes: *Intense Class Schedule* and *Balancing Study Workload*.

Intense Class Schedule

This code refers to the perception the students hold about the course schedule being overly demanding or packed, with limited time for breaks, assignments, or review. Students experiencing an intense class schedule often feel overwhelmed by the rapid pace of lessons, frequent exams, or the volume of material covered within a short timeframe. This issue is further exacerbated when the course meets only twice a week, leaving insufficient time to process and absorb the content. Students believe that spreading classes across more days would alleviate this pressure, allowing for more review time and a better balance in managing their workload.

Participant A highlighted the importance of spreading out class sessions across more days, stating:

> *"I'd probably try to take a Monday, Wednesday, Friday instead of a Tuesday, Thursday. That would be more helpful for my learning."*

Similarly, Participant C expressed a desire for more frequent class meetings due to the intensity of the material covered:

> *"I think that the course is very hard on its own, like. It's a lot of material that we have to learn, and I just wish there was more lecture time, or that I had it like 3 times a week instead of just twice. I just think that the material and class time is a lot."*

Participant G suggested adjustments to the class duration and structure to improve student engagement:

> *"maybe making the class last 50 minutes instead of an hour and 15. Yeah, I feel like at some point students just like stop paying attention so closely after some time. Maybe having like a 5-minute break in the middle of the class to kind of recharge. because it's a lot of stuff that we cover in Class, A lot of information. So, for us to be able to understand everything during the class, we need to be paying a lot of attention. And attention can like disappear after some time, you know?" I would rather have it 3 days a week.*

These quotes acknowledge that difficulties in statics can arise from the course schedule itself. Students believe that some of the challenges they face could be reduced if the course schedule was shifted to better accommodate their needs.

Balancing Study Workload

This sub-theme refers to the challenge students face in managing the demands of their coursework, assignments, and exams, with the additional time that engineering statics problems require. A typical statics course includes weekly homework assignments, and two mid-term exams and a final throughout the semester, all of which require extensive problem-solving practice. Homework problems often involve multi-step calculations and require a strong grasp of fundamental concepts, making them time intensive. The midterms and final exams test cumulative knowledge, adding to students' workload. Students struggle to find an effective balance between their study time for statics and other responsibilities, such as homework for other courses or personal commitments. This issue is particularly pronounced when students have frequent tests, large assignments, or a heavy reading load across multiple subjects. Balancing study workload becomes more difficult when students feel they are unable to allocate enough time to thoroughly understand the material, leading to last-minute cramming or incomplete preparation.

Participant D reflected on their study habits and acknowledged the advice given by the professor to dedicate more time to reviewing course material after class:

> *"I don't put a lot of time like after class and stuff like that. I only do the homework and I only study when I have a test coming. But I think if this is something that the professor tells us every day, that we have to after the class spend one to two hours reviewing what we went over in class and try to understand it and practice a few problems on whatever topic we did, I think that would be really helpful."*

Participant E expressed their challenges with homework, particularly the tasks they found tedious, and described the emotional impact this had on their motivation:

> *"So...things that aren't going well for me just pertaining to the course - it just takes me a while to do the homework, and then and this is also more of a personal issue. But I still think it plays a role here is that I get very discouraged, and then I just don't want to do the homework, and then I struggle with centroids because it is tedious to calculate".*

Similarly, Participant F shared:

> *"I have been studying a day before the quizzes and exam, so that definitely takes an effect on my grade of, you know, I study the day before, and it shows. And so that's what I would like to do is to study a week prior. I just don't have the time because of all my classes, and I feel like just engineering in general, like, it takes a lot of time, and I'm trying to do my homework. But I'm trying.*

Participant F further revealed that the challenge of managing multiple academic responsibilities simultaneously:

> *"I've had a test at least once a week, and so I'm trying to focus on that test while also, like trying to do my homework at the same time, also trying to understand the material. And so I feel like it's just a lot to handle."*

These transcripts show that statics problems require a significant amount of time, and students face challenges in balancing the time needed to understand the course content with the demands and expectations from their other engineering courses. This struggle aligns with the theme of workload and schedule strain, where the course's high demands are difficult to balance, leading to stress and making it hard for students to maintain focus on their learning.

Theme 4: Course Delivery and Instructional Support

This theme refers to the difficulties the students face with how course content is presented and their expectations from the additional resources that are provided to assist their learning. The theme is subdivided into two subthemes: *Teaching Style* and *Ineffective Supplementary Learning Aids*.

Teaching Style

This code captures how the instructor delivers content and engages with students in the statics course. It includes factors like the clarity of explanations, the use of practical examples, the level of student interaction, and how accessible the professor is for questions. Students described some challenges such as teaching style not matching their learning preferences, especially when the lectures feel unengaging, examples are unclear, or when they feel discouraged from asking questions.

Participant A shared:

"I don't know if this is all statics professors, but specifically mine [professor name removed] isn't really open to questions, and when he is, he's kind of hostile about it. So maybe that would, I think just creating an environment where it's OK to ask questions, because questions aren't really welcomed, like even to clarify. So that's kind of tricky. So, I mean, it makes sense to write down the questions and ask them later, but they're less relevant then.".

Participant A noted a discrepancy between the difficulty level of questions covered in class and those expected during assessments. They stated:

"I learn a lot from him, but I think he chooses interesting practice problems considering that what he does in class is a lot harder than what he puts in the exam. So I don't think he focuses on the correct practice for us just because it's kind of a level of difficulty that makes it like seem like you're teaching a different thing compared to the exam, just because it's so much simpler."

Participant B inferred that the introduction of quizzes at checkpoints should be introduced to help students familiarize themselves with the expectations of the course. The participant explained:

"Honestly, I don't think it would hurt to have little quizzes in there. I would see them as little learning checkpoints that way it adds a little more pressure to make sure you're actually staying on track and learning. It makes sure you have a full grasp on the topic."

Participant C's transcript showed that the teaching style on some concepts in engineering statics differs from how they had learned the same concept in another course, which poses as a challenge in their understanding of the course.

"I learned centroids in a different way, and the way that they are taught in this class are a little confusing for me. I learned them in Calc 2, and they are different from Calc 2. Also, I feel like there could be, even though it takes me a long time to do homework, there could be a little bit more homework, So we could cover a little bit more outside of class."

The students perceive that the teaching style of their instructors, the absence of regular learning assessments, and inconsistencies in the integration of statics concepts across different subjects all pose significant challenges to their learning experience.

Ineffective Supplementary Learning Aids

This sub-theme highlights the challenges students face with additional learning resources, such as recitations, online tutorials, or study materials, which may fail to effectively support their understanding of statics concepts. Students reported that recitation sessions led by teaching assistants often focus on solving problems without adequately clarifying underlying concepts or engaging students in active learning. Additionally, some online resources or external materials were perceived as misaligned with the course content, making it difficult for students to translate theoretical knowledge into practical problem-solving skills. These ineffective supplementary learning aids were perceived to hinder students' ability to grasp essential statics concepts, negatively impacting their overall learning experience and mastery of the subject. Recitation sessions are offered weekly as optional supplementary learning aids, intended to provide students

with additional support outside of regular lectures. While these sessions are not graded, they serve as an opportunity for students to seek help with difficult concepts and homework problems. However, as described by participants, the effectiveness of these sessions is limited by their unstructured nature.

Participant A reported that the recitation sessions, which are additional supplementary learning aids put in place by the instructor, do not fulfill their purpose because the instructor's style of facilitating the homework sessions does not necessarily help the students to learn better. The participant explained:

> *"So let's say I get there and then the teacher gets there as well. And he says OK, if you have any questions on homework "this number" feel free to ask me. So I just work on my homework and I usually never ask anything because I don't necessarily know what to ask. I don't know what I'm doing is wrong, so I just keep working on it. And then sometimes he doesn't say anything at all like because nobody asked him the question. And then other times, maybe someone will ask a question and he'll either just answer from his desk or like he'll go help the student like individually instead of like putting it on the board or something or talking about it to the whole class. So that's kind of bad. But yeah, it's very hands-off. I think I would do just as well or just as bad without him being present."*

Participant B held the same opinion about the recitation sessions:

> *"I guess I don't find our recitation super helpful. Because it's more so everyone just comes to recitation. Our recitation TA, he more so is like, "Okay, if you have any questions I will help." But other than that, it's just pretty much ends up being work time. So it's not what I'm used to for recitation compared to where it's like, "okay, we're gonna do this problem and this problem." as, like an example, I think that would be a bit more helpful. I mean, I don't really think it's helping much."*

Participant E held similar sentiments about the recitation and using additional resources such as the internet.

> *"It's kind of the same issue with the recitation sessions, like, you know, like there's websites that will explain how to find a centroid. Usually, I'm not usually able to just read the website and then translate that to doing homework problems and getting them right and all that. Because I believe I tried it once, and then it didn't really help me.*

Students believe that supplementary learning aids such as recitations and internet resources are ineffective in their understanding of the course.

Overall, students perceive that the course delivery and the instructional support, which is intended to facilitate their learning, contribute to the challenges they encounter in an already demanding course like engineering statics.

Discussion

The results of this study are divided into four themes which are responses to the research question that explored students' description of the challenges they encounter in engineering

statics. Our findings align with prior literature, which indicates that difficulties in applying knowledge from prerequisite courses can hinder students' understanding in subsequent courses. To address this, we recommend that instructors of core engineering courses allocate time to revisit key prerequisite concepts that are foundational for success in follow-up courses [2], [24]. Additionally, previous research suggests that students' perceptions of a course's difficulty can impact their learning and approach to the material [25]. Instructors could incorporate visual learning aids and spatial tools [26], [27] when teaching abstract concepts to change students perceptions of the course difficulties' as well as incorporate reflection prompt activities [28], [29]. These strategies would not only assist students in overcoming some of the challenges they encounter but also enhance their ability to recall prior knowledge and apply it effectively to solve statics problems.

We also acknowledge past literature that suggests students can face challenges when they experience an intense class schedule that lacks breaks [30]. Literature also suggests promoting collaboration in smaller groups. While we understand that instructors must cover a significant amount of material in a limited time, incorporating authentic learning activities [31] or active learning strategies can help maintain student engagement and facilitate learning [32], [33].

Engineering instructors should also recognize that students often contend with an already demanding schedule, which may be further compounded by teaching styles and the learning environment. Statics instructors can support students by adopting strategies such as scaffolded instruction [34], which breaks complex problems into manageable steps, or utilizing visual aids [26], [27] and interactive problem-solving sessions [35] to reduce cognitive stress and overload. Additionally, instructors should consider designing recitation sessions to focus on reinforcing foundational principles, fostering a supportive learning environment, and providing personalized instruction to help students strengthen their understanding of key concepts [36]. By emphasizing core ideas and addressing individual weaknesses in a student-centered format, such recitation sessions can play a crucial role in improving performance [6]. Instructors can also foster a supportive learning environment by encouraging open communication, offering clear guidance, and providing regular feedback [37], [38], [39]. These measures can help students navigate the challenges of a rigorous course like statics.

In our prior research [7], we proposed the introduction of mentors to help students overcome difficult courses and concepts, and during the pilot implementation on this recommendation, preliminary findings revealed students greatly valued the role of mentors in addressing some of the challenges they faced with the course. For example, participants shared the following insights: "*I just don't know how to do something until I talk to the Mentor from learning community.*"; "*the learning community is a kind of place where like if I get stuck on the homework, I can go there and get it figured out, and not all hope is lost, I can just go ask my mentor*". These preliminary findings is also supported by literature that suggests that instructors can adopt the introduction of past successful students to act as mentors or learning assistants to current students who are struggling in a course [40], [41]. In our future work, we plan to explore the impact of learning assistants more comprehensively by comparing the perceptions of both instructors and students. This investigation aims to identify and address recurring challenges in engineering statics. By reducing the high rate of failing grades and providing actionable recommendations for statics instructors, this work seeks to improve students' learning experiences and manage their expectations of the course.

Recommendations

The following summarizes our recommendations on improving the challenges students face in engineering statics based on this study's findings:

Revisit Prerequisite Concepts: Instructors should allocate time to revisit prerequisite concepts.

Incorporate Visual Learning Aids and Spatial Tools: Statics instructors can adopt the use of visual aids and spatial tools to help students understand abstract concepts.

Use Engaging Teaching Activities: Statics instructors can adopt the use of engaging activities such as interactive problem-solving sessions, scaffolded problem-solving, and authentic and active learning activities to maintain student engagement and enhance students' collaboration.

Introduce Learning Assistants: We also propose that instructors can pair students up with past successful students to act as mentors or learning assistants. These can provide additional support to help struggling students.

Revisit the Design of Supplementary learning Aids: Finally, we recommend instructors re-evaluate the design of the recitation and tutorial sessions. These sessions should be designed to provide emphasizing core ideas and address individual weaknesses in a student-centered format.

While these recommendations may not fully address all the challenges students have outlined, they can serve as a valuable starting point for instructors seeking to mitigate some of the difficulties students encounter in challenging courses.

Limitations

This study has certain limitations inherent to qualitative study. Firstly, the study relied on a small sample size from only one institution in a midwestern university in the United States. While the findings may offer insights relevant to similar contexts, they are not universally generalizable. Furthermore, relying on interviews as the primary data collection method could lead to response bias, as participants might feel inclined to give socially desirable responses. Despite these limitations, the study offers meaningful insights into the challenges students face with engineering statics. In response to some of the difficulties identified, we have implemented a mentoring program, where students are paired with past successful students who have completed the statics course. This initiative aims to provide additional support outside the classroom and help students navigate challenging concepts. However, we have not yet systematically assessed the effectiveness of this program, and future research will be needed to evaluate its impact on student learning and performance.

Future Work

Building on our preliminary findings from the pilot implementation of mentorship programs, future work should adopt a more comprehensive approach to improving student success in engineering statics. In addition to examining the role of peer mentors and learning assistants, we plan to assess the effectiveness and clarity of the current curriculum content, as well as instructional practices across different faculty members teaching statics. This will involve

evaluating how well the course structure aligns with student needs and exploring opportunities for incorporating active teaching methods that promote deeper understanding.

Furthermore, future research should investigate the impact of various pedagogical strategies, including structured recitations, interactive problem-solving sessions, and revised lecture plans tailored to support diverse learning styles. By comparing student and instructor perspectives, we aim to develop actionable strategies that not only enhance mentorship effectiveness but also improve course delivery, ultimately fostering better learning outcomes in engineering statics and notoriously difficult courses in general.

Conclusions

This study explored challenges experienced by students in engineering statics. Four themes emerged from semi-structured interviews with the seven students enrolled in the course over two semesters at an R1 midwestern university. The findings emphasize the importance of addressing foundational knowledge gaps, revisiting prerequisite concepts, and implementing strategies that reshape students' perceptions of difficult courses. By addressing the challenges identified in this study, educators can help students navigate the rigors of engineering statics, ultimately reducing failure rates and fostering a more engaging and effective learning experience. This work underscores the need for intentional instructional practices that not only improve academic success but also prepare students for the demands of their engineering careers.

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