Exploring High DFW Rates in an Engineering Statics Course: Insights from Faculty and Teaching Assistants.

Ibukunoluwa Eunice Salami[1], Segun Samuel Oladipo[2], Dr. Logan Perry[3]

1: Graduate Student Researcher, Department of Civil and Environmental Engineering, University of Nebraska-Lincoln

2: Graduate Student Researcher, Department of Mechanical Engineering, University of Nebraska-Lincoln

3: Assistant Professor, Department of Civil and Environmental Engineering, University of Nebraska-Lincoln

Abstract

Engineering statics is a branch of engineering mechanics that focuses on the effects of forces on objects, systems, and structures that are at rest or in equilibrium. Statics introduces complex engineering topics and concepts and is typically a foundational course in civil, architectural, and mechanical engineering programs. However, it faces a notable occurrence of D, F, and Withdraw (W) grades, with a total of 26.9% of engineering students at an R1 midwestern university receiving one of these grades since 2016. The purpose of this study is to explore the perceptions of faculty instructors and teaching assistants regarding the high DFW rates in engineering statics at a midwestern R1 University. The qualitative research design employed involved in-depth interviews with faculty members and TAs from mechanical engineering who are responsible for teaching students enrolled in this course. The interviews were structured to understand the instructors' personal experiences teaching the course, including strategies they have employed to help students be successful. The study seeks to answer the research question: What perceptions do the instructors (faculty and TAs) involved in engineering statics hold concerning the high DFW rates? The research revealed that a perceived inadequate foundation in prerequisite courses and challenges in providing individualized attention to students due to large class sizes contribute to the failure rate in the course. Faculty members and TAs also discussed the need for students to take advantage of the resources that were designed for the course. The findings from this study have the potential to enhance student retention, graduation rates, and academic performance, taking the first steps in transforming the statics course into a catalyst for success in students' engineering pursuits.

Keywords

Statics, DFW, Concepts, Instructors, Qualitative, Interventions

Introduction

Engineering statics is a branch of engineering mechanics that focuses on the effects of forces on objects, systems, and structures that are at rest or in equilibrium [1]. Statics introduces complex engineering topics and concepts and is typically a foundational and a pre-requisite course in civil, architectural, and mechanical engineering programs [2]. Students are expected to lean on their background in mathematics, physics, and engineering for this course [3]. The course curriculum covers specific topics relating to forces, equilibrium, and rigid bodies. Students often find this course very challenging, and there is usually a high occurrence of failure as compared to other courses (i.e., D, F, and a Withdraw grades), [4], [6] which can affect students' GPAs and their decision to continue in engineering or transfer to another major [4]. At an R1 mid-western university in the United States, analysis revealed

that 26.9% of engineering students received a D, F, or withdrew from the statics course since 2016.

Research has indicated the need to investigate the influence of instructors and teaching strategies to assist students in navigating and approaching engineering statics [6]. This study aims to address this gap by exploring the perceptions of faculty instructors and teaching assistants regarding the high DFW rates in engineering statics at a midwestern R1 University.

The qualitative research design employed involved in-depth interviews with faculty members and TAs from mechanical engineering who are responsible for teaching students enrolled in this course. The interviews were structured to understand the instructors' experiences teaching the course, including strategies they have employed to help students be successful.

The study seeks to answer the research question:

> What perceptions do the instructors (faculty and TAs) involved in engineering statics hold concerning the high DFW rates?

The findings from this study will add to existing literature on engineering statics, propose solutions that will help to reduce the high rate of D, F and W grade in a statics course which would help improve students' retention in engineering.

Background/Literature Review

Engineering Statics

Engineering statics is a foundational course in engineering mechanics. Engineering statics uses Newtonian physics to design and analyze objects, systems, and structures in terms of motion, deformation, and failure [1]. In addition to this, the course allows students to gain abilities in problem solving and mathematical modelling, which provide the foundation for later courses and have the potential to benefit students in their career endeavors as an engineer [5]. The term "statics" refers to particles and rigid things in equilibrium (i.e., immobile or at rest) [6].

Engineering statics includes more advanced topics than mechanics concepts taught in high school physics classes, including: "rotational equilibrium and the inclusion of moments of forces and couples"; and "the interplay between forces and couples (i.e., statically equivalent combinations of loads) that produce similar motions, deformations, or reactions" [9]. Statics emphasizes analyzing problems with multiple bodies that need to be separated or disassembled, whereas physics focus on analyzing problems involving single bodies [1], [7]; Statics also considers the exploration of bodies that have finite dimensions and experience rotational motion, whereas physics concepts concentrate on bodies subject to translational motion [1], [7]. These differences illustrate that statics requires a much deeper comprehension of fundamental concepts of force and equilibrium compared to physics [7].

Engineering statics also serves as a prerequisite course for dynamics and mechanics of materials and a foundation for more advanced engineering courses [7]. Due to the importance of this course, research has revealed that engineering instructors in follow-up courses after statics believe that students poor background in engineering statics plays a role in their retention rate in those courses and in engineering discipline in general [7], [8].

Challenges Students Face in Statics

In a bid to understand the challenges students face in statics, existing research has aimed to investigate the course from the students' point of view. Statics problems typically require students to analyze the problem statement and then create a model of the system using a free body diagram to display the salient forces on the body. However, research revealed that students misinterpret statics problems due to deficiencies in the knowledge of forces and moments for specific joints, weak mathematics skills, and difficulty with mentally visualizing or conceptualizing forces [7], [9].

Students also cited their inability to break large statics problems into smaller steps as a challenge they faced in the course [10]. The study also revealed that students' difficulty understanding certain statics concepts such as internal forces, multi-body systems, and setting up equilibrium equations proved to be the most daunting. Venters & McNair [10] further explained that students' study habits influence their performance in the course. This was confirmed by a separate study, which introduced the use of think-aloud problem-solving processes to improve students' success rate in statics [11]. A study by Hanon et al. [12] revealed that students attributed their poor performance in the course to the new learning approaches, which were significantly different from the methods they were accustomed to in high **school.**

Interventions in Teaching Statics

Due to the daunting nature of engineering statics, instructors have been advised to adopt the use of different strategies in teaching the course to improve the success rate. Steele et al. [13] proposed the use of statics concept inventories to perform a diagnostic assessment on students understanding of statics concepts. Their intervention demonstrated that integrating paper-based worksheets to assess students' prior knowledge using statics concept inventories was highly effective in enhancing students' subsequent performance in the course.

A recent systematic literature review by Cuddy & Deters [14] revealed that while there is no perfect solution, different universities across the United States, Columbia and Germany have attempted to improve students' success rate by adopting 42 different interventions. 22 of these interventions had a positive impact on the students, 12 had a negative impact on the student's success, and while 8 were categorized as having no effect on improving the outcomes of the course. Examples of these interventions included "the introduction of flipped learning style, writing for conceptual understanding, additional exposure, the use of hands-on laboratories, the incorporation of online resources, constant review of in-class structure by including rapid feedback or in-class concept checks, [and] the use of supplemental instruction such as the use of peer-assisted learning". The literature review revealed that the use of supplemental instruction proved to be the most effective. Steif [9] proposed that instructors should consider incorporating cognitive approaches such as concept questions and practical activities which are designed to help students conceptualize notions of forces and moments. Venters & McNair [10] proposed that instructors should improve the course curriculum by explaining in detail potential activities that would help in simplifying the course concepts and adopting situated learning instructional approach so students can convert the theoretical concepts to real-life concepts.

Recently, California State University instructors discovered that 80% of the students were on the path to failing in the middle of the semester. The instructors took immediate action by re-evaluating their approach to the course after observing the mid-term grades. They found that

students were struggling with the course prerequisites and were also influenced by their negative perceptions about succeeding in the course. To avoid a high rate of D, F and W grades in the course, the instructors commenced the adoption of a mastery-based approach in helping students fully grasp the concepts of statics. According to a newsletter from the school's website, they also redefined their instructional methods to focus on fundamentals and prerequisites. Additionally, they implemented a dynamic and interactive teaching approach and worked to improve students' perceptions of the course. By the end of the semester, their efforts paid off: 85% of the students excelled in the final exams, class attendance significantly improved, and students developed a more positive attitude towards the course [15].

Despite these various interventions and studies, there remains a gap in understanding the instructors' and teaching assistants' perspectives on the failure rates in engineering statics [6]. Most existing research has focused on students' viewpoints or specific interventions, but the insights and experiences of those who teach the course are less explored [6]. This study will address this gap by investigating the perceptions faculty and teaching assistants hold regarding the failure rate in the course and recommend new strategies that may help to improve students' success in the course.

Methodology

Methods

This study employed a qualitative approach. Qualitative research "focuses on inquiry, which focuses on meaning in context, requires a data collection instrument that is sensitive to underlying meaning when gathering and interpreting" [16]. In the context of this study, our data collection instrument involved the use of semi-structured interviews which captured the perceptions of the participants. In this study, we are interested in investigating faculty and teaching assistants' perceptions of the high failure rates in engineering statics [6] and recommending new strategies for improving student success [17] and the retention rate in engineering [4].

Participants and Settings

The participants in this study included two instructors and two teaching assistants involved in teaching statics during the spring 2024 semester at an R1 midwestern University in the United States. We acknowledge the limited number of participants for this study, and it is not our intention to make any generalizable conclusions from this data; instead, we present our findings to help shed more light on the insights of instructors involved in teaching statics with the major aim of improving the understanding of teaching practices, challenges, and strategies in this subject area.

Data Collection

The researchers adopted the use of semi-structured qualitative interviews as a 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.

Data Analysis

Transcripts were analyzed using thematic analysis [18] and broken into themes to give a rich description of the experiences of the instructors and the teaching assistants in teaching engineering statics. We took an inductive approach for data analysis as the codes and themes were developed to showcase the participants' perspectives based on their lived experiences [19].

Reflexivity

The first and third authors of this paper are engineering education researchers while author two is a mechanical engineer. Author 1, an African with experiences in complex engineering courses is particularly interested in researching how such courses impact student success and engineering careers. Author 2 also an African is a mechanical engineering graduate student who struggled with prerequisite courses in mechanics. Author 3 is a white, engineering faculty member from the United States who struggled with statics in his own undergraduate career. All three authors acknowledge that their biases and experiences could influence their interpretation of the participants' responses. To address this, they adopted the method of bracketing by writing down their experiences and actively focusing their interpretations on the interpretations of the participants. They also discussed their interpretations of the findings on multiple occasions to maintain the integrity of their coding [20].

Findings

Based on the experiences of the faculty and TAs, five themes were developed which captured the perceptions of the instructors and teaching assistants on the high rate of D, F and W grades in the statics course. They are described below.

Difficulty in Introducing Practical Applications

We defined this code as the inherent challenges within the course related to the difficulties instructors experienced in connecting the theoretical aspect of statics to practical applications. In other words, instructors experienced complexities in simplifying abstract concepts into relevant real-world scenarios that would enhance students' comprehension and understanding of the course concepts.

One of the instructors explained that students' D, F and W grades in statics can be avoided if students are introduced to real life applications of statics. One of the instructors said:

> *"If there are some real experiments that would be helpful. It will be very good because the knowledge from the textbook is just some of that kind of theory. OK, you learned the theory, but you do not know how to use them in the daily life." PT2*

The instructor also explained that students need to be able to apply their theoretical knowledge into practical experiments. The instructor explained this by emphasizing:

> *"This class is just theory knowledge. If they have some real practice like build some real stuff that would be more helpful." PT2.*

The instructors held further beliefs that students need to be introduced to the methods they would adopt in solving statics problems. Instructors believe that successfully achieving this helps to reduce the high rate of D, F and W in the course.

> *"What methods that they can use to solve questions? I believe in textbook and the class professor should also introduce the methods and the knowledge to them." PT2*

Hence, bridging the gap between theory and practice in statics courses during the instructional approach is crucial for enhancing student comprehension and reducing poor grades. By incorporating practical experiments and real-life applications into the curriculum, instructors can provide students with a more comprehensive and engaging learning experience that better sets them up for success.

Huge Class Size

We defined this code as the difficulties the instructors experience due to the high enrollment in the course, making it difficult to simplify the course for the students. The instructors contended that the high enrolment rate for statics makes it difficult for them to personalize the instruction to assist students who are struggling with the course. The instructors explained:

> *"The sad thing about statics is because it is like a foundational class for engineering, the class size for statics is usually huge, so personalizing statics for students would become a challenge." PT1*

Another quote revealed:

> *"But then again, statics class size is too huge that it becomes unrealistic for the professor to ask individual students to go outside. So today we learnt about moments, let's go outside in the real world and see how moments are being applied in the real world and then come, let's talk about it. Yeah, so the class size for statics is too huge for such an engagement." PT1*

These quotes highlight that large class sizes can impact students' learning, as their ability to grasp concepts varies. This makes it challenging for instructors to break down concepts and address individual learning concerns, contributing to the increasing rates of D, F, and W grades in the course.

Weak Foundation in Prerequisites

This code captures the challenges arising from students perceived inadequate foundation in prerequisite courses, which influences their performance in statics. A solid foundation in these prerequisites is crucial for success in statics, but the transcripts indicated that students do not always come to statics with this strong foundation. Participants consistently pointed to weak foundations in high school courses such as mathematics, calculus, algebra, physics as major factors contributing to the high rate of D, F and W grades. One of the participants explained:

> *"I think sometimes the problem is not necessarily the concept of statics. The problem is their background in mathematics. So, statics involves a lot of things. It involves a lot of mathematical theorems, integration, calculus. You need to know trigonometry and you need to revise them before the class" PTA1*

This quote explains that students' success is heavily dependent on the students' background in mathematical theorems and applications. They also explained that students need to review

these principles before they come to every class. Failure to do so could influence their understanding and lead to poor performance.

Another instructor reinforced that the high rate of failure can be traced to their background in the prerequisites. They said:

> *"We assume that they'd have a good understanding of calculus, but in fact, they don't. One of the standard exam problems in calculus is to determine the area, the centroid of an area by integration or the moments by integration. That problem, it killed most of the students, they just do not know calculus." PT2*

A follow up quote by another participant also revealed that the students' weak foundation in prerequisites such as in performing calculus operations like integration plays a major role in the high rate of D, F and W.

> *"Some students don't know how to do the integration. That's actually striking. So, they have not sufficiently built that skill. I think that's most of the reason" PI1*

Some attributed this lack of prerequisite knowledge to learning during the COVID pandemic. The instructor explained:

> "*They obviously all pass with some good grades in calculus. But in fact, they know very little. I think this is not a statics problem. It originated from probably high school, you know, if someone was in high school during COVID, then that student was not trained very well on high school math and physics*" *PT2*

Based on these transcripts, the instructors hold the beliefs that insufficient training in prerequisite courses has contributed to the poor grades students receive in statics. Failure to fully understand these prerequisites plays a huge role in the high rate of D, F and W grades in the course.

Inconsistent Use of Available Resources

This theme reflects the instructors' perceptions of how students utilize the resources provided to assist them. The transcripts from the instructors revealed that students do not fully utilize the available resources intended to help them understand the course material, which contributes to the high rates of D, F, and W grades. The instructors noted students' attendance in recitations and lectures and their willingness to take notes in class. Recitation sessions were introduced to provide students with opportunities to discuss areas of confusion with teaching assistants. Despite this, both teaching assistants and instructors reported that very few students attended the recitations. A quote by one of the instructors reflects this:

> *"Every week there's the recitation class, the students should come for recitation and in recitation I should give them some hints about the homework. But actually, not many students join the recitation. Most times, there is just no more than 10 students joining the recitation every week" PTA2*

Another instructor reported that students do not take part in recitations, and this affected their grades. The instructors perceived that because recitations were optional, it affected students' motivation to fully take advantage of them. The instructor explained:

> *"A lot of students also don't show up during recitation hours, because for most professors, recitation isn't compulsory, right?" PTA1*

Another instructor explained that while recitations help students collaborate with other students, they still held on to studying independently, which affected them taking full advantage of the resources.

> *"In recitation they can feel free to discuss each question, talk to each other. Yeah, that is the advantage of recitation, but I would say most students prefer independently finished homework." PTA2*

The instructors also attributed the high rate of D, F and W grades to poor attendance. The transcript revealed:

> *"For my lectures, the attendance has been dropping year by year" PT2;*

Another participant reinforced concerns about the declining rate of student attendance on the course, despite efforts to persuade them to attend lectures. The instructor shared:

> *"Personally, due to the recent trend and students not coming to the class, I actually sent an email last Friday, because the attendance trend is decreasing currently. It is like 20%. Two to three years ago, it was like 30% absence." PT1*

A similar quote by another instructor reaffirmed that even when the students do attend class, they do not show interest in taking notes or revising the lecture materials:

> *"They don't attend class, sometimes some of them do, or at times, many of them don't. Also, once they are in the classroom, they don't always take notes, and even if they take notes, do they go back and work on them or not? I have some doubt" PT2.*

They also hold the belief that students might have other commitments that affect them investing sufficient efforts into their homework. The participants reported:

> *"They don't take much time and effort on statics. Homework is very important. I mean through homework you can use what you've learned from class to solve those questions. That's the way to consolidate what they learned from class. But I can feel they didn't spend much time and effort on the whole work. Yeah. And maybe they are busy" PTA2*

The instructors also emphasized the importance of informing students from the beginning about the realities of the course. They urged students to start revising their math skills early and to dedicate significant time to statics. When students enter the class with a relaxed attitude and are unaware of the course's difficulty, it becomes challenging for them to change their approach and increase their effort midway through the semester. This issue is particularly problematic when they face complex topics that require extensive preparation and practice. The instructors also believed that when students feel overwhelmed by their workload, they may not prioritize revisiting foundational concepts, which contributes to their struggle in statics.

> *"If students come in and they are not made to understand that, hey, it's going to be a tough program, so start revising your maths and spend a lot of time on it. If you are not fully informed about this from the onset and you start the class with a relaxed*

> *attitude, the probability of you ramping up your attitude to be more serious and commit more time to it right in the middle of the semester is low. Especially where we are doing a centroid problem or where we are doing a lot of integration problems, and you have like 6-7 questions to solve. Are you now going to revise integration and come and solve those problems on short notice? And a lot of students feel like, hey, I have enough on my plate already. I don't have time to go and revise all of these things to come and take this course" PTA1*

Another instructor attributed the poor grades of the students to the efforts they put towards the course, however, those who take advantage of the resources provided perform better in the course.

> *"So those who take advantage of it, you actually see improvements in their grades, which is good. But for those who don't, there's isn't much we can do, but there are those who don't put in effort and that is that is the other side of the spectrum where they don't do well, and that's the weakness of the class I guess" PTA1*

Instructors believe that statics grades can be improved when students dedicate sufficient time and effort to the learning materials of the course such as homework questions. The instructor explained that:

> *"I don't think statics is very difficult. It just takes time, takes effort and homework" PTA2*

Therefore, instructors hold the perception that students inconsistent use of resources also influences the high rate of D, F and W grades in the course.

Attention to Details

We defined this quote as students' ability to respond to instructions and feedback from their instructors. The transcript revealed that students do not adhere to instructions in their homework submission, which affected the grades they receive for their submissions. A quote from one of the instructors showed that:

> ***"****So, for example, since the beginning of class I keep reinforcing the idea that when you have a statics problem, setting up the problem is really important. Don't just start writing equations and writing numbers for me. Set up your problem, draw your free body diagram. But today I will start grading the new set of homework that is due today, and I bet you there's still going to be more than half of the students not drawing free body diagrams.****" PTA1***

This instructor explained they must penalize students for not following instructions and this plays a huge role in students getting D, F and W grades.

Another instructor reiterated that submissions not in line with the rubrics or instructions are graded accordingly. The instructor expresses disappointment in students' ability to respond to instructions effectively:

> *"You tell students to solve one question per page so that it's legible, yet students will come with seven questions solved on a single sheet of paper." PTA1*

The instructors also perceive that students' reluctance to read the textbook could be impacting their overall understanding of the course which is reflected in their grades. The transcript revealed that:

> *"I even feel they didn't read the textbook carefully and I mean after class they didn't take time to read textbook because textbooks have a lot of details. They can use the knowledge from the textbook applications. I feel like they don't read the textbook." PTA2*

Overall, the instructors hold the belief that students have the potential to do better in statics if they can follow the instructions and spend more time with the course.

Discussion

The results of this study were divided into five themes, which are responses to the research question that explored the perceptions instructors of statics hold on the high rate of D, F and W grades in the course. Our findings are consistent with literature that revealed: students with poor backgrounds in prerequisites have a tougher experience with engineering statics at the university level [4]; the need for using different interdisciplinary approach that would help students understand how to apply the theoretical concept in statics to practical applications [21], [22]; the need for students to take full advantage of resources in improving their success rate in statics [23] and the influence of a huge class size in teaching a complex engineering course [24].

We observed that the findings reported by the instructors of this study often employed a deficit-based approach [25], which we believe influences their perceptions regarding the high incidence of D, F, and W grades in the course. We contend that instructors would benefit from adopting asset-based approaches [26], as these could facilitate the implementation of interventions designed to enhance their teaching methods and thereby improve the rates of D, F, and W grades. Asset-based approaches might include leveraging students' existing strengths and knowledge to tailor instructional strategies [27], creating opportunities for collaborative learning that build on students' diverse experiences [28], or providing targeted support that addresses individual learning needs in different situations and encourages growth [25], [28], [29]. For instance, instructors could implement formative assessments that help identify and build on students' areas of proficiency [30] or design assignments that allow students to apply their skills in real-world contexts [31]. The findings from this study are also a call to action for statics instructors to incorporate new intervention methods to help reduce the high rate of D, F and W grades in the course. The interventions could incorporate the different approaches discussed in previous literature such as the use of supplemental instruction, or blended style learning with a major emphasis on recitation [14]. It is also important for statics instructors to consciously reevaluate their instructional approach by adopting the use of a mastery-based approach [15] or authentic learning activities [31] and reflection activities [27] which are proven to be effective in helping students understand core course concepts in engineering. Past literature also emphasizes that successfully helping students improve their understanding of fundamentals and prerequisites reduces the high rate of D, F and W in statics [7], [15].

We believe that when students hold a negative mindset about a widely proclaimed difficult course, it can affect their performance and their success rate in the course [25]. We believe that statics instructors can promote an asset-based approach to reduce the high rate of D, F and W in the course by shifting their focus from what the students are doing wrong to how

they can introduce practical applications to the course and assist students that are struggling with prerequisites of the course [5]. The instructors can also consider incorporating the use of reflective prompts which would help to access students learning and monitor their progress in the course [17]. The study by Haron et al., [5] also proposes the use of technology-based teaching in helping students rise above the difficulties of learning engineering statics. Success rate in engineering statics can also be achieved by the introduction of learning assistants. This includes a community of past successful students in engineering statics to serve as tutors to current students [32], [33]. This way, students who are hesitant to approach their instructors can be encouraged to collaborate with their peers or with students who have succeeded in a notoriously difficult course to improve their success rate. The learning community can also build a platform that will help in improving student's mindset about the course difficulties and expectations. From the transcripts, it is evident that statics instructors need to reinforce the practical benefits of engineering statics so students can make connections between the concepts and real-life applications of the course. This will enable students to appreciate the usefulness of the course, reinforce the importance of the course for subsequent mechanics' courses, [4] and potentially reduce the attrition rate of students in engineering [12].

We also discovered that the teaching assistants and faculty hold a few differing views on factors that affect students' success in statics. While the teaching assistants believe that the responsibilities students are faced with contributes to them not spending enough time with the course, on the other hand instructors believe students disposition is a major player in them receiving poor grades in the course. The teaching assistants also believe instructors abilities to personalize the course would assist the students while faculty instructors believe they have done all they can to help the students. This is an area that can be researched further.

Recommendations

The following summarizes our recommendations for improving student success in engineering statics based on this study's findings.

Apply an asset-based approach in teaching statics: Instructors need to shift their focus from the students' deficiencies so they can facilitate the implementation of interventions, which may help students overcome the negative perceptions they might have about the course and improve their success rate.

Incorporate new intervention models: Instructors should consider adopting different instructional approaches that may help improve students' success in the course. These instructional methods could help facilitate students' understanding of prerequisites and the practical applications of statics. Examples include, but are not limited to, the use of supplemental instruction, the use of a mastery-based approach, the introduction of authentic learning activities, the use of reflective prompts, and technology-based teaching focusing on fundamentals and prerequisites.

Introduction of learning assistants: To reduce the high rate of D, F and W grades in engineering statics, instructors can adopt the use of learning assistants who are past students that have succeed in statics to act as mentors and tutors to current students who are enrolled in the course.

Limitations

The study presented in this paper has certain limitations inherent to qualitative studies that should be acknowledged. Firstly, the study relied on a small number of instructors and teaching assistants from one university in the midwestern United States. Though the results may be transferable to other contexts, findings from this study are not applicable to all contexts. Additionally, we acknowledge that the use of interviews as the primary data collection method could introduce responder bias, as participants may feel compelled to provide socially desirable answers. Nonetheless, despite these limitations, the study provides valuable insights in exploring the high rate of D, F and W grades in engineering statics.

Future Work

The authors of this study would like to propose that follow-up studies investigate the impact of learning communities, the use of new instructional methods or interventions in teaching statics, and the perceptions of the students regarding statics. We believe that these areas also have the potential to impact the of D, F and W grades and performance in engineering statics.

Conclusion

This study explored the high rate of D, F and W grades in an engineering statics course from the perspectives of the instructors by adopting the use of semi-structured interviews. Five themes were developed which captured the perceptions of the instructors. However, we propose that instructors of engineering statics consider an asset-based approach in teaching engineering statics by introducing new interventions such as supplemental instruction, active learning strategies, or the use of learning communities to help students navigate this notoriously difficult course. The findings and recommendations from this study have the potential to help improve the success rate in engineering statics, students' general academic performance, and the retention of students in engineering.

References

[1] Daniel. W. Baker and W. Haynes, *Engineering Statics Open and Interactive*. 2024.
[2] L. Doyle and T. L. Nilsson, "Lessons Learned from Changing Content Delivery Methods in Engineering Statics," in *123rd ASEE Annual Conference & Exposition*, New Orleans, LA, Jun. 2016, p. 20.
[3] J. H. Hanson and J. M. Williams, "Using Writing Assignments to Improve Self-Assessment and Communication Skills in an Engineering Statics Course," *J. Eng. Educ.*, vol. 97, no. 4, pp. 515–529, 2008, doi: 10.1002/j.2168-9830.2008.tb00997.x.
[4] H. Haron, A. M Shaharoun, and H. Harun, "The Learning Issues in Engineering Statics," *Int. J. Sci. Soc.*, vol. 1, Jan. 2009, doi: 10.18848/1836-6236/CGP/v01i02/51392.
[5] Paul. S. Steif and A. Dollar, "A new approach to teaching and learning statics," in *American Society for Engineering Education*, Nashville, Tennessee, 2003.
[6] C. L. Rao, J. Lakshinarashiman, R. Sethuraman, and S. M. Sivakumar, *Engineering Mechanics: Statics and Dynamics*. PHI Learning Pvt. Ltd., 2003.
[7] P. S. Steif, "An articulation of the concepts and skills which underlie engineering statics," in *34th Annual Frontiers in Education, 2004. FIE 2004.*, Oct. 2004, pp. F1F-5. doi: 10.1109/FIE.2004.1408579.
[8] E. Asa, "Designing a New Course: Construction Statics and Mechanics," in *9th International Conference on Engineering Education*, San Juan, PR, Jul. 2006, pp. 7–11.

[9] K. Higley, T. Litzinger, P. Van Meter, C. B. Masters, and J. Kulikowich, "Effects of conceptual understanding, math and visualization skills of problem-solving in statics," in *2007 ASEE Annual Conference & Exposition*, Honolulu, Hawaii, 2007.
[10] C. Venters and L. McNair, "Learning Statics: A Cognitive Approach," in *2010 ASEE Southeast Section Conference*, Blacksburg, Virginia, Apr. 2010, p. 10.
[11] T. Litzinger *et al.*, "Improving students' ability to model during problem-solving in statics," in *2009 ASEE Annual Conference & Exposition*, Austin, Texas, 2009.
[12] H. N. Hj. Haron, A. M. Shaharoun, M. Puteh, and H. Harun, "Does Motivation Affect Students' Understanding and Performance in Engineering Statics?," *Procedia - Soc. Behav. Sci.*, vol. 56, pp. 191–203, Oct. 2012, doi: 10.1016/j.sbspro.2012.09.646.
[13] K. Steele M., S. R. Brunhaver, and S. D. Sheppard, "Feedback from In-class Worksheets and Discussion Improves Performance on the Statics Concept Inventory," *Int. J. Eng. Educ.*, vol. 30, no. 4, pp. 992–999, 2014.
[14] C. Cuddy and J. Deters, "Literature Review of Student Success in Statics Courses," in *2023 ASEE Midwest Section Conference*, Lincoln, Nebraska, Sep. 2023.
[15] Cal State LA, "Nearly 80% of Students Failed a Mid-Term. Something Had to Be Done." [Online]. Available: https://www.calstatela.edu/ecst/nearly-80-students-failed-mid-term-something-had-be-done
[16] S. B. Merriam and E. J. Tisdell, *Qualitative Research: A Guide to Design and Implementation*, Fourth Edition. Jossey-Bass, 2016.
[17] L. Perry, I. Salami, H. A. Diefes-Dux, G. Panther, and K. Mowat, "Examining the Implementation and Impact of Reflective Practices in Engineering Courses: Insights from Faculty and Teaching Assistants," in *2024 ASEE Annual Conference & Exposition*, Portland, Oregon: American Society for Engineering Education, Jun. 2024. Accessed: Jul. 05, 2024. [Online]. Available: https://par.nsf.gov/biblio/10505265-examining-implementation-impact-reflective-practices-engineering-courses-insights-from-faculty-teaching-assistants
[18] V. Braun and V. Clarke, *Thematic Analysis*. SAGE Publications, 2021. Accessed: Apr. 25, 2024. [Online]. Available: https://us.sagepub.com/en-us/nam/thematic-analysis/book248481
[19] K. Charmaz, "Constructivist grounded theory," *J. Posit. Psychol.*, vol. 12, no. 3, p. 299, 2016.
[20] F. M. Olmos-Vega, R. E. Stalmeijer, L. Varpio, and R. Kahlke, "A practical guide to reflexivity in qualitative research: AMEE Guide No. 149," *Med. Teach.*, pp. 1–11, Apr. 2022, doi: 10.1080/0142159X.2022.2057287.
[21] W. Johnson and P. Goeser, "AC 2007-906: INTRADISCIPLINARY TEACHING IN THE ENGINEERING STUDIES CURRICULUM: APPLYING NUMERICAL MODELING TECHNIQUES TO STATICS PROBLEMS," in *American Society for Engineering Education*, Louisville, Kentucky, 2007.
[22] A. Kamat and N. Yari, "Methods for teaching statics," presented at the 2019 ASEE Zone I Conference & Workshop, Apr. 2019. Accessed: Jul. 29, 2024. [Online]. Available: https://peer.asee.org/methods-for-teaching-statics
[23] B. Lani and C. M. de Vries, "Evaluating the Effectiveness of a Statics Recitation Course," presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul. 2021. Accessed: Jul. 29, 2024. [Online]. Available: https://peer.asee.org/evaluating-the-effectiveness-of-a-statics-recitation-course
[24] P. C. Boylan-Ashraf and J. R. Haughery, "Failure Rates in Engineering: Does It Have to Do with Class Size?," presented at the 2018 ASEE Annual Conference & Exposition, Jun. 2018. Accessed: Jul. 29, 2024. [Online]. Available: https://peer.asee.org/failure-rates-in-engineering-does-it-have-to-do-with-class-size

[25] L. B. Limeri *et al.*, "Growing a growth mindset: characterizing how and why undergraduate students' mindsets change," *Int. J. STEM Educ.*, vol. 7, no. 1, p. 35, Jul. 2020, doi: 10.1186/s40594-020-00227-2.
[26] F. López, "Asset-Based Pedagogy," in *Handbook of Educational Psychology*, 4th ed., Routledge, 2023.
[27] H. Budinoff and V. Subbian, "Asset-based Approaches to Engineering Design Education: A Scoping Review of Theory and Practice," in *ASEE Virtual Annual Conference and Exposition, Conference Proceedings*, Jul. 2021. Accessed: Aug. 01, 2024. [Online]. Available: https://repository.arizona.edu/handle/10150/663512
[28] D. L. Scott, R. Sharma, F. Godwyll, J. Johnson, and T. Putman, "Building on Strengths to Address Challenges: An Asset-based Approach to Planning and Implementing a Community Partnership School," *J. High. Educ. Outreach Engagem.*, vol. 24, no. 2, Art. no. 2, Sep. 2020.
[29] N. Idiaghe, Y. Brijmohan, I. E. Salami, and J. Deters, "Exploring Mechanical Engineering Students' Perceptions of Preparedness for Work," in *ASEE Conference & Exposition*, 2023.
[30] R. E. Bennett, "Formative assessment: a critical review," *Assess. Educ. Princ. Policy Pract.*, vol. 18, no. 1, pp. 5–25, Feb. 2011, doi: 10.1080/0969594X.2010.513678.
[31] I. E. Salami and L. A. Perry, "Assessing Priorities in Engineering Design Through Augmented Reality," in *2023 ASEE Annual Conference & Exposition*, Baltimore, Maryland, USA, Jun. 2023, p. 11. doi: English.
[32] T. Azzam, M. D. Bates, and D. Fairris, "Do learning communities increase first year college retention? Evidence from a randomized control trial," *Econ. Educ. Rev.*, vol. 89, p. 102279, Aug. 2022, doi: 10.1016/j.econedurev.2022.102279.
[33] V. Bracho Perez, "Expanding Faculty-Student Interactions in Statics: An Exploratory Study of a Statics Course with Learning Assistants," *FIU Electron. Theses Diss.*, Mar. 2022, [Online]. Available: https://digitalcommons.fiu.edu/etd/4944

Biographical Information

Ibukunoluwa Eunice Salami is a PhD Student in Engineering Education Research at the University of Nebraska-Lincoln and graduate research assistant at the department of Civil and Environmental Engineering. She completed her undergraduate studies in Systems Engineering at the prestigious University of Lagos, Akoka and her master's in industrial engineering at the University of Benin, Ugbowo (both Universities are domicile in Nigeria). Her research interests include transfer of learning, transition from school (both undergraduate and postgraduate) to work for engineering students and . She is also interested in understanding how engineering students and faculty utilize technological tools to facilitate their understanding of theoretical engineering concepts.

Segun Samuel Oladipo is a master's student in Mechanical Engineering at the University of Nebraska-Lincoln. He earned his undergraduate degree from Ladoke Akintola University of Technology in Ogbomosho, Nigeria. With 13 years of industry experience in Nigeria, he is also a certified project manager. Currently, he serves as the Pollution Prevention Technical Assistance Coordinator for the Departments of Civil and Environmental Engineering, Mechanical and Materials Engineering, and the Nebraska Industrial Assessment Center. At UNL, his research includes tutoring students to apply theoretical concepts in mechanical engineering to real-life scenarios.

Dr. Logan Perry is an Assistant Professor of Engineering Education in the Department of Civil & Environmental Engineering. His work contains a unique blend of engineering education and civil engineering projects. Dr. Perry's current work centers on understanding how students transfer their knowledge between engineering school and work. This is supplemented by his interests in virtual and augmented reality, and diversity, equity, and inclusion in the context of engineering. Dr. Perry’s expertise in both the engineering education and civil engineering domains provides him with a unique skillset that drives his interests in learning and technical engineering work.

Acknowledgements

This material is based on work supported by funds from the University of Nebraska-Lincoln Fred J. Kelly Fund.