3-28-2022

Expanding Faculty-Student Interactions in Statics: An Exploratory Study of a Statics Course with Learning Assistants

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EXPANDING FACULTY-STUDENT INTERACTIONS IN STATICS: AN EXPLORATORY STUDY OF A STATICS COURSE WITH LEARNING ASSISTANTS

A thesis submitted in partial fulfillment of

the requirements for the degree of

MASTER OF SCIENCE

in

MECHANICAL ENGINEERING

by

Valerie V. Bracho Perez

2022

To: Dean John L. Volakis
College of Engineering and Computing

This thesis, written by Valerie V. Bracho Perez, and entitled Expanding Faculty-Student Interactions in Statics: An Exploratory Study of a Statics Course with Learning Assistants, having been approved in respect to style and intellectual content, is referred to you for judgment.

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ACKNOWLEDGMENTS

I would like to thank the members of my committee for their support and their unwavering confidence in my abilities to successfully complete this thesis. Dr. Strong consistently pushed me to think more critically about my work and guided me in making my work the best that it could be. Dr. Boesl and Dr. Dickerson always asked the tough questions, which helped me immensely during the analysis and dissemination of my work. I would also like to thank the participants of the study who opened their classroom to me and were willing to share their experiences with me. Without them, this study would not have been possible.

ABSTRACT OF THE THESIS

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Professor Alexandra Strong, Major Professor

Statics is one of the first fundamental engineering classes within the ME undergraduate curriculum, in which a student’s performance in the course can impact their overall academic success. Recent efforts to enhance students learning in fundamental engineering courses have included integrating Learning Assistants (LAs), undergraduate peers who have previously excelled in the course, into the course's instructional team. The purpose of this Master's thesis is to explore the enactment of a Statics classroom with LAs, the interactions that characterize it, and the impact it has on the students and instructional teams. A qualitative case study of a Statics course with LAs was conducted leveraging Kranzfelder’s Teaching Discourse Moves Framework to deductively and inductively analyze the data collected. The value of having LAs within Statics was prevalent throughout the interactions and from the perspective of the LAs, instructors, and students. However, Statics remains a challenging course for the students, and the LAs remained untapped resources for many in the course. The results of this study have implications for engineering departments and instructors.

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I. INTRODUCTION

Statics is one of the first engineering classes that Mechanical Engineering (ME) students encounter during their undergraduate curriculum. As both a prerequisite and corequisite to most required ME courses, Statics has the potential to impact an engineering student's trajectory in ME and their overall academic success (Wingate et al., 2018). For many students, Statics can be a challenging subject due to its heavy reliance on pre-requisite courses that are also considered challenging for students, such as trigonometry, algebra, and physics (Steif, 2004; Vasquez et al., 2012). To that end, Statics acts as a barrier course within the ME curriculum that “weeds out” individuals from the engineering field, with one study reporting drop, fail, and withdrawal (DFW) rates of 36% (Benson et al., 2007; Marra et al., 2012). In addition, in a study at the Georgia Institute of Technology, grades in Statics were found to be positively correlated with students’ final GPA (i.e., higher grades in Statics lead to higher GPAs) (Wingate et al., 2018). Given both the challenging nature of Statics and its potential for affecting a students’ academic career, we must examine approaches for better supporting students' learning experiences during Statics.

Statics courses are often large enrollment courses, and as such, there is typically a reduced opportunity for faculty-student interactions. Faculty-student interactions significantly impact student learning (Wang et al., 1990). On one end, limited faculty-student interactions can have detrimental effects within a course, such as leading to an increased rate of withdrawals and a decreased sense of engagement (Fenollar et al., 2007; Pavlacic & Buchanan, 2017; Twigg, 2013). The experience of having limited engagement with the faculty member can also lead students to become passive learners, which has shown to be one of the least effective learning methods for students (Chi, 2009; Magana et al., 2018; Sloan, 2020). However, high amounts of faculty-student interactions have been shown to positively impact student engagement with the course content as well as their overall experiences in the course (Pavlacic & Buchanan, 2017; Sloan, 2020). Hence, in a course as high-risk as Statics, there is a need to examine ways of enhancing the quantity and quality of faculty-student interactions.

Existing efforts to enhance the student experience within fundamental engineering courses, such as thermodynamics and introduction to microcontrollers, have included the use of Learning Assistants (LAs) (Orser et al., 2020; Wendell et al., 2019). LAs are undergraduate students who facilitate discussions between students in a classroom, encouraging active engagement with the course material and supporting their peers' learning (*LAA | About GPEs*, n.d.). In particular, these LAs have previously taken and succeeded in the course they are supporting, meaning they have firsthand experience with the course and its content. As LAs are peers of the students within the classroom, and they assist faculty as facilitators of class discussions and activities, LAs can enhance the student experience alongside their instructors. For example, various studies have shown that classrooms with LAs tend to have lower failure rates, higher student retention, and improved student perception of their learning (Freeman et al., 2014; Laudenbach, 2020; Orser et al., 2020). Therefore, in a barrier course such as Statics, LAs could serve as a critical student learning support role.

LAs also can and have played an important role in increasing faculty-student interactions in the classroom. Umbach and Wawrzynski (2005), for instance, found that student engagement was higher in courses where faculty use active and collaborative learning techniques, which are essential aspects of the LA Model (Umbach & Wawrzynski, 2005). In a study on the impact of LAs on undergraduate STEM students, results showed that LAs spent more time engaged in constructive teaching modes, which gave students the opportunity to take an active role in the classroom as well as a greater sense of community with the faculty, LAs, and other students (Sloan, 2020). Yet, there are overall limited studies on the roles of and impacts of LAs in foundational, and often "barrier," engineering courses. The interpersonal experiences stemming from faculty-LA-student interaction and the impacts they have on students are particularly important to consider in engineering curricula, where retention of students is low, particularly in "barrier courses" such as Statics. As such, examining how LAs are being utilized in Statics is essential to understand how they are impacting the student learning experience and promoting faculty-student interactions. The purpose of this Master's thesis is to explore how a Statics classroom with LAs is enacted and what interactions between students, LAs, and Instructors characterize that classroom. This thesis study will also explore how the course interactions impact students' and the instructional team's experiences in the course. Specifically, through the use of a case study research design, this thesis study answers the following research questions:

1. What type of interactions characterize a Statics classroom with an instructional team that includes a faculty member and LAs?
2. How do the course interactions impact students' and the instructional team's perceptions about how they individually experience the course?

By more deeply investigating the role of LAs within a Statics classroom, this work has the potential to capture what it's like to be a student, instructor, and LA in a Statics classroom with LAs and the ways in which LAs are supporting student learning. This study will have implications for engineering departments and instructors already considering or already implementing LAs into their courses.

II. LITERATURE REVIEW

Statics: A High-Risk Barrier Course

Statics, one of the first engineering mechanics courses in the ME curriculum, has broadly been classified as a fundamental course in which students develop a deep understanding of concepts and engineering tools, such as moments and free-body diagrams. These concepts and tools are foundational to other engineering courses. Another critical component of Statics is the opportunity for students to develop problem-solving skills that are essential in analyzing and solving engineering problems (Vasquez et al., 2012). However, many studies have shown that Statics is a challenging course for students, making it difficult for them to develop the knowledge and skills necessary for future academic success in the ME curriculum (Benson et al., 2007; Marra et al., 2012; Vasquez et al., 2012; Wingate et al., 2018).

Challenges of Statics

Statics has proved to be a challenging subject for many due to its heavy reliance on pre-requisite courses that are also challenging for students, such as trigonometry, algebra, and physics (Mayar, 2016; Vasquez et al., 2012). This challenge arises because these pre-requisite courses, particularly physics, cover only a very small margin of what Statics entails (Dollar & Steif, 2004; Mayar, 2016; Steif, 2004). In these courses, students have not been exposed to the critical thinking and conceptual understanding required by some of the problems students encounter in Statics (Mayar, 2016; Steif, 2004). In Mayar's study on a re-design of a Statics course, they state that:

> *"Statics is different from the preliminary Newtonian physics in many ways, and it's not all about mathematical modeling skills either. It combines both of them and also utilizes critical thinking in order to solve the real-world problems." (pg. 2)*

Many of the students carry with them general ideas learned in Physics into Statics, and when confronted with real-world problems, they may not know how to apply them. Additionally, any misconceptions that arose during their Physics courses may also be carried into Statics courses, which adds additional barriers as these misconceptions must be broken down first before they are replaced with the concepts in Statics (Dollar & Steif, 2004; Mayar, 2016). Due to key differences between the knowledge and skills students gain in Physics compared to the knowledge and skills needed in Statics, Statics becomes a very challenging subject for many students. In Paul Steif's study on the concepts and skills which underlie Statics, he states that many engineering instructors have a common misconception that "Statics must be a breeze for students who have passed physics" (Steif, 2004, pg. 1). He further states that "this deceptive simplicity of Statics can lead [...] to instruction that is insufficiently sensitive" to the differences between what is taught in Physics and what is taught in Statics (Steif, 2004, pg. 1).

Another key reason why Statics is a challenging subject for many students lies within the course content itself. In Statics, many of the concepts build up from foundational concepts such as forces and moments (Brose & Kautz, 2011; Mayar, 2016; Steif, 2004). During these early stages of the course, students are vulnerable to developing misconceptions as they are just starting to grasp the concepts of the course. In Brose's study addressing student difficulties in Statics, they state that "misconceptions that arise at this early stage, [they] tend to persist and thereby influence the ability of students to master more advanced concepts" (Brose & Kautz, 2011, pg. 3). Statics becomes increasingly more challenging as the course progresses, particularly for students who may not have fully grasped the concepts early on in the semester. This is particularly important to consider as some students already come with misconceptions from previous Physics courses, as mentioned, which could make it more difficult for students to grasp the concepts at the beginning of Statics. Given the challenges outlined here, this Master's thesis seeks to explore ways to better support student learning within Statics.

Impact on Students' Academic Success

Drop, fail, and withdrawal (DFW) rates are one of the ways in which the difficulties of Statics and its impact on a student's academic success can be observed. A study at the University of Texas-Pan American showed that Statics had an average failing rate of 39.3% within the ME department, with about 25% of the students receiving D's or F's and 14.3% of students withdrawing from the course (Vasquez et al., 2012). Similar results were found in a study conducted at Clemson University, which reported a DFW rate of 36% for one semester (Benson et al., 2008). These statistics are not isolated to a single university or to a specific university type (Benson et al., 2007; Dollar & Steif, 2004; Mayar, 2016; Steif, 2004; Vasquez et al., 2012). Overall, Statics is a high-risk engineering foundational course in which many students struggle with, and many have to retake.

Typically known as “barrier courses,” Statics and other foundational engineering courses and their inherent difficulties are cited as reasons for leaving engineering (Marra et al., 2012; Wingate et al., 2018). A study at a large U.S. institution found that nearly 19% of the students that leave engineering attribute their decision to course difficulty, with many stating that they were unhappy with their grades in engineering and that the curriculum was too difficult (Marra et al., 2012). This same study found that students typically leave engineering about 13.5 months into the degree, which is around the time that students begin to take these “barrier courses.” These results further emphasize how Statics and other fundamental engineering courses can impact students' decisions to persist in engineering (Marra et al., 2012; Wingate et al., 2018).

For those students that remain in ME, the impact of a student’s performance in Statics extends beyond the course itself and into the ME curriculum. The DFW rates in Statics are cause for concern as the knowledge and skills developed are essential for future academic success in ME (Vasquez et al., 2012; Wingate et al., 2018). A study of mechanical engineering students at Georgia Institute of Technology found that a student’s final GPA was positively correlated with their ME foundational courses, such as Statics, Dynamics, Mechanics, and Physics (i.e., the higher their grade in Statics, the higher their overall GPA at graduation) (Wingate et al., 2018). A closer examination of the data showed that for students whose final GPA was less than a 3.0, Statics had the most significant impact on their GPA (Wingate et al., 2018). Time to graduation for ME students also tends to increase as students’ grades in foundational engineering courses decrease, with the average time to graduation being about five years (Wingate et al., 2018). From this and other studies, we are reminded of the impact of fundamental engineering courses, such as Statics, on academic success indicators (i.e., GPA) and on students' time to degree. As a result, this study is designed to deeply examine one approach for supporting students' learning and overall experience within Statics.

Transforming the Learning Experience with Learning Assistants

Recent efforts to better support students' learning experiences within fundamental engineering courses have integrated Learning Assistants (LAs) into the instructional team (Orser et al., 2020; Wendell et al., 2019). LAs are undergraduate students who have taken and excelled in the course for which they are Learning Assistants. The Learning Assistant Alliance describes LAs as (*LAA | About GPEs*, n.d.):

> *"Undergraduate students, who, through the guidance of weekly preparation sessions and a pedagogy course, facilitate discussions among groups of students in a variety of classroom settings that encourage active engagement."*

Learning Assistants first emerged at the University of Colorado Boulder (CU Boulder), where Dr. Valerie Otero created a model which "integrates goals of teacher recruitment and preparation, course and curriculum transformation, discipline-based educational research, and departmental and institutional change" (Otero, 2015). This model launched into a full program in 2003 at CU Boulder and was specifically implemented with the purpose of transforming "large-enrollment courses so that enrolled students have ample opportunities to work in small groups to articulate, defend, and modify their ideas about a relevant problem or phenomenon" (Otero, 2015 pg. 107). With their firsthand experience with the course, their unique position as peers of the students within the class, and their potential for transforming large-enrollment courses, LAs can play an essential role in enhancing the student experience alongside their assigned faculty member (i.e., the instructor of the course with LAs) (*LAA | About GPEs*, n.d.; Otero, 2015; Sabella et al., 2016).

Role and Benefits of LAs in the Classroom

LAs play critical roles in supporting educational transformation toward active learning and student-centered learning environments and enhancing their peers' learning experience (*LAA | About GPEs*, n.d.). More broadly, in a meta-analysis of 255 studies, student performance was found to be higher in active learning-based STEM classrooms when compared with traditional lecture-based STEM classrooms (Freeman et al., 2014). Failure rates were lower in active learning classrooms, 21.8%, compared to 33.8% in traditional lecture-based classes. Similar results were seen in active learning-centric chemistry courses with LAs. Students did better overall in the course than those in traditional lecture-based courses (Laudenbach, 2020). Lecture-style courses also resulted in higher DFW rates compared to the chemistry courses with LAs. These studies illustrate how the implementation of active learning, as well as active learning with LAs, can positively impact the student learning experience.

Another area in which institutions have sought to support through the implementation of LAs is in increasing the number of faculty-student interactions, which has been shown to be critical for student learning. In Wang and colleagues'(1990) meta-analysis of 179 articles on variables related to learning outcomes, the results indicated that the classroom elements that were most important to learning outcomes were those that were directly linked to students' engagement in the course (Wang et al., 1990). Of the 30 characteristics studied, the results showed that positive and productive student/teacher interactions were one of the top elements that contributed to good learning outcomes (Wang et al., 1990). Some studies have explored the implementation of LAs, or other similar active learning elements, in large introductory (Pavlacic & Buchanan, 2017; Sloan, 2020; Umbach & Wawrzynski, 2005). Otero states that:

> *"LAs support large-enrollment courses by effectively increasing the teacher-to-student ratio and allowing for multiple collaborative working groups, either in a large lecture hall with the lead instructor present or in LA-led, small-group meetings that take place at various times and places throughout the week." (Otero, 2015 pg. 108)*

Overall, these studies have reported that the implementation of LAs increased student engagement, offered interpersonal experiences for the students, and allowed the student to take an active role in their education and build a sense of community (Pavlacic & Buchanan, 2017; Sloan, 2020). For example, in Pavlacic and colleagues' (2017) study on the redesign of a psychology course with LAs, it was found that courses with LAs offered "a unique and interpersonal experience for all involved individuals" (Pavlacic & Buchanan, 2017). The LAs were able to help students throughout the course, help students to form connections with upperclassmen of their respective majors and decrease faculty to student ratio, which allowed for more faculty-student interactions (Pavlacic & Buchanan, 2017). Additionally, students in classes with LAs were retained at higher rates than students in classes without LAs (Sloan, 2020). These interpersonal experiences stemming from faculty-LA-student interaction and the impacts they have on students are particularly important to consider in engineering curricula, where retention of students is low, and particularly in "barrier courses" such as Statics, which impact a student's desire to leave engineering.

Within engineering specifically, research on the impacts of the implementation of LAs in engineering courses is limited (Orser et al., 2020; Wendell et al., 2019). A recent study at a large state research institution examined an introductory electrical and computing engineering course that implemented LAs (Orser et al., 2020). At the start of the study, the course had a failure rate of 15.8%. After implementing LAs, course ratings increased, and failure rates decreased to 14.3%. Given the limited studies of LAs, and the focus of those studies on student performance metrics, there is an opportunity and a need to better understand the day-to-day effects of LAs in a fundamental course such as Statics. Therefore, this study provides a deep understanding of the interactions that are occurring in the Statics classroom with LAs, as well as the students/instructors/LAs perceptions of these interactions.

III. THEORETICAL FRAMEWORK: TEACHING DISCOURSE MOVES

Overview

The diversity of discourse that instructors use within the classroom is at the center of faculty-student interactions and one of the features of classroom learning (Kranzfelder et al., 2019). Kranzfelder and colleagues define the diversity of discourse that instructors use as *teacher discourse moves* (TDMs) or the "epistemic tools that can mediate classroom discussions" (Kranzfelder et al., 2019, pg. 2). This thesis is grounded in the Teaching Discourse Moves (TDMs) framework developed by Kranzfelder and colleagues as a lens through which to examine the interactions between instructional teams and students in Statics.

Previous Work on TDMs

Kranzfelder's framework was developed based on previous research on TDMs, specifically in the K-12 space (e.g., Herbel-Eisenmann et al., 2013; Krussel et al., 2004 and others). Herbel-Eisenmann and colleagues (2013), for example, describe the classroom as a place where the teacher (i.e., anyone who has the role of managing the classroom) has more power than their students, specifically in shaping the classroom discourse. In this classroom, the TDMs are actions that teachers take to open up and lead classroom discourse (Herbel-Eisenmann et al., 2013). TDMs, based on this framing, can be used to 1) increase the quantity and quality of student talk about the course content, 2) help teachers access their students' thinking in a non-evaluative way, 3) provide students with opportunities to help other students develop new understandings of the course content, and 4) empower students as active participants in their learning experience (Herbel-Eisenmann et al., 2013). Within mathematics courses, Krussel and colleagues' (2004) define the purpose, setting, forms, and consequences of TDMs as the following:

1. *"The purpose of a discourse move may be to set structural boundaries on the discourse, to change the discourse focus, to build classroom norms for discourse, to change the structure, to influence participation in the discourse, etc."(pg. 309)*
2. *"The setting for a discourse move takes into account both physical and temporal constraints.[...] Includes consideration of the physical layout of the classroom, structural boundaries, established classroom norms for discourse."(pg. 309)*
3. *"The form of a teacher's discourse move may be a verbal challenge, probe, request for clarification, request for elaboration, request for participation, an*

invitation for attention, piece of information, hint, or direction. They could also be nonverbal."(pg. 309)

4. *"The consequence of a teacher's discourse move may include a shift in the cognitive level of a task, a shift in the discourse focus, a shift in attention to a misconception in an individual's concept image, a shift in the structure of the discourse, etc. These consequences can be immediate or long-term and can be both cognitive and affective."(pg. 309)*

Across these and other TDM-focused studies, the where and how the TDMs take place matters, but ultimately TDMs are flexible, and instructors should consider a wide range of impacts they could have on their students.

Kranzfelder and Colleagues' TDM Framework

Using this and other existing literature on TDMs in K-12, Kranzfelder and colleagues (2019) developed a TDM framework that categorizes dialogue and discourse that is occurring within undergraduate classrooms between teachers and students. This framework is operationalized within a codebook (Appendix A), which details teacher- and student-centered codes that help categorize the discourse moves seen in a classroom. Teacher-centered codes include moments in which the instructor talks about the content of the course, such as connecting how the current topic links to future or past topics, showing the students real-world examples of the concepts they're studying, or sharing study tips with the students. Student-centered codes include moments in which the instructor is prompting the students to talk about the content of the course, such as asking students to connect course content to broader ideas, clarify topics, or associate the current topic with previous topics. Although this framework was not developed while studying fundamental engineering courses like Statics, the recognition of the diverse ways instructors (and LAs) can interact with students will enable this thesis to capture the interactions between students and LAs/instructors in the setting of a Statics classroom with LAs.

Many aspects of the TDM framework, particularly Kranzfelder and colleagues' (2019) TDM framework, are based on active learning environments, which align well with the purpose of this thesis. As mentioned in the first sections of this thesis, existing efforts to enhance the student experience within fundamental engineering courses have included the use of LAs (Orser et al., 2020; Wendell et al., 2019). When exploring the active learning component of the LA model in engineering specifically, the impacts of the implementation of LAs have focused on performance metrics (e.g., DFW rates, persistence in engineering, student outcomes). However, details on how the classroom is enacted and the interactions students have with their instructor, and the LAs have not been studied. Therefore given that active learning is a core component of a Statics classroom with LAs, the TDMs framework supports the analysis of the discourse moves and the consequences of those moves on the experience of all of those involved (i.e., student, instructor, LA) (*LAA | About GPEs*, n.d.).

Overall, Kranzfelder and colleagues' (2019) TDMs framework was used in this thesis to explore interactions between students and the instructional team within the different data sources of the case study. In particular, Kranzfelder and colleagues' (2019) observation protocol was adapted for the Statics classroom data and was used to deductively and inductively analyze the observation and interview data. Further details on the overall research design are detailed in the following section.

IV. METHODS

Overview

To develop a rich and deep understanding of the interactions that occur among students, LAs, and instructors in a Statics classroom and the impacts of those interactions, a case study of a Statics course with LAs was conducted. As defined by Merriam and Tisdell (2016), a case study is "an intensive, holistic description and analysis of a single, bounded unit" (Merriam & Tisdell, 2016, pg. 233). In the context of this Master's thesis, the case study design enabled the development of a detailed and rich description of a single semester of a Statics course from varying perspectives. Through the use of qualitative data sources, this research design aimed to answer the following research questions:

1. What type of interactions characterize a Statics classroom with an instructional team that includes a faculty member and LAs?
2. How do the course interactions impact students' and the instructional team's perceptions about how they individually experience the course?

In particular, this case study included four data sources: 1) class observations, 2) instructor interview, 3) LA focus group interview, and 4) student interviews. The in-class observations were used to gather insights on how the LAs were being integrated into the course and the types of interactions students, LAs, and instructors are having in the classroom. The interviews were conducted to gather first-hand accounts about how the students, LAs, and instructor individually experienced the Statics course. The data analysis process began with deductively analyzing the observations using the Teaching Discourse Moves (TDM) framework and then inductively analyzing them to allow for themes specific to a Statics course to emerge from the data. The interviews were analyzed using the findings from the observations as well as the same process of deductive and inductive analysis using the TDM framework. This study was conducted with the approval of Florida International University's Institutional Review Board (IRB). The IRB approval number pertaining to this study is the following: IRB-21-0363. All other documents pertaining to this approval can be found in Appendix B. The following sections will detail my positionality within the research, the site and sample of this study, the data collection process, and the data analysis process.

Positionality

As a researcher, I recognize that my previous experience as an LA and student in Statics impacted how I approached my research, framed my study, analyzed my data, and reported on results. Having experience in educational research and practice as both a former LA and scholar, I have come to know that all students learn differently. During my time as an LA, I had to change my way of teaching to best fit the needs of the students I was helping. I believed that as an LA, my role was to ensure that I found a way to help students understand the difficult concepts of Statics, no matter how many times I had to review the same concepts with them. Additionally, in my time as a researcher, I have reviewed multiple teaching techniques, all of which have particular purposes but do not work for everyone. A core motivation for this work is my desire to contribute to designing an education system that ensures all students receive the best education possible through a system that is tailored to their needs and best prepares them to complete their engineering degrees and pursue successful careers. As a Mechanical Engineering graduate student who not only took Statics in my undergraduate education but also served as an LA for a Statics section, I recognize the complexities in better supporting students within this fundamental engineering course. However, I believe that my perspective as a Mechanical Engineer and my understanding of not only the content of the course but also as an educational researcher, allow me to examine this course design from an interdisciplinary perspective.

For this study, I used audit trails and memoing techniques to record any decisions being made and why they are being made throughout the data collection and data analysis process, which helped me reduce and keep track of potential biases. I shared these memos with critical peer de-briefers and enlisted their help during the data analysis process. Enlisting the help of a critical peer reviewer provided the study with perspectives that were different from my own and helped uncover any potential biases within my work (Creswell & Miller, 2000).

Site and Sample

This study was conducted in the Mechanical Engineering Department at Eastern Public University (EPU). EPU is a Minority Serving, 4-year public institution that enrolls over 40,000 students in its undergraduate programs. The engineering college enrolls around 5,000 of those students. Specifically, this study took place over a semester in a Statics course in which LAs are used. Statics is offered year-round (i.e., every Fall, Spring, and Summer semester) and is typically taken by engineering students in the third or fourth semester of their undergraduate careers. LAs have been used in specific Statics course sections, depending on the instructor, since Spring 2019. For this thesis, data was collected in a single section of Statics in the Fall 2021 semester. The course section was selected based on the instructor's teaching experience with Statics, their status as full-time faculty, and the number of semesters they had been using LAs in their classroom. The instructor was a full-time faculty with at least three semesters' worth of experience teaching Statics, as well as at least a semester of teaching with LAs. A screening survey was distributed through Qualtrics to instructors that were scheduled to teach Statics with LAs in Fall 2021. The survey questions included:

1. Will you be teaching Statics this upcoming semester?
    a. If so, how long have you been teaching Statics?
2. Do you use LAs in your courses?
    a. If so, how long have you been using LAs in your courses?

The selected course section was a mini-term Statics course, which is an accelerated version of the course that takes place over 7 weeks rather than the usual 14 weeks. Apart from the selection criteria previously mentioned, the 7-week mini-term was chosen after discussion with the instructor, who had planned to structure future Statics courses the same way as this course (i.e., lectures and LA session as two different components of each course meeting). This is important to note because this study may provide insights into the student and instructional team experiences and interactions that could be used in future implementations of the course. During this discussion, details of the study, such as the frequency of observations and future interviews, were reviewed, and consent to observe the course was obtained.

The section selected had one instructor, 2 LAs, and enrolled over 50 students. Given that this was a mini-term course, the class met twice a week for 2 hours and 45 minutes, as compared with the 1 hour and 15-minute twice a week class meetings that are common in semester-long versions of the course. The first two hours were the lecture portion, where the instructor went over the theory and concepts of the course and some example problems. The last 45 minutes of the course were LA sessions, where students worked on a graded pre-made worksheet, and the LAs and instructor moved around the room, helping students with the worksheets.

Data Collection

This qualitative case study included four data sources: 1) class observations, 2) instructor interview, 3) LA focus group interview, and 4) student interviews. The data was collected over a nine-week period. Table 1 presents a timeline for data collection, alongside the different components of the course (e.g., concepts covered, exams). The subsequent sections describe each of the data sources in detail. (see Table 1).

Table 1: Timeline of Data Collection

	Data Collection	Topic Covered	Important Dates
Week 1	IRB Study Information Distributed Observations 1 & 2	Ch.1 Fundamental of Statics, Ch.2 Force Vectors (2D and 3D)	
Week 2	Observations 3 & 4	Ch.3 Equilibrium of Particle (2D and 3D) Ch.4 Force System Resultants	
Week 3	Observations 5 & 6	Ch.4 Force System Resultants	
Week 4	Observations 7	Ch.5 Equilibrium of Rigid Body Ch.6 Structural Analysis (Trusses, Frames, and Machines)	Mid-term Exam
Week 5	Observations 8 & 9	Ch.6 Structural Analysis (Trusses, Frames, and Machines)	
Week 6	Observations 10 & 11	Ch.7 Internal Force, Ch.8 Friction	
Week 7	Observations 12	Ch. 9 Center of Gravity and Centroid Ch. 10 Moment of Inertia	Final Exam Final Week of Classes
Week 8	Interviews with LAs and Students		Grades Posted
Week 9	Interview with Instructor		

In-class Observations

Class observations are essential for this study because observations allow a researcher to collect data about the phenomenon under study at the moment it occurs, in this case, as student-instructor-LA interactions take place within Statics (Merriam &

Tisdell, 2016). Therefore, observations allowed me to study the classroom in the context in which it naturally occurs.

In-class observations were conducted in every course meeting of every week of the mini-term. In the first class, I introduced the study and provided students with consent forms that described the study procedures. The script used to introduce the study and the consent form can be found in Appendix C and D, respectively. Students were then able to decide whether they wanted to participate in the study. Those who chose not to participate were entirely removed from all observations in which they appeared. During the observations, I was a silent observer, taking field notes on everything, including, but not limited to, the structure of the classroom, conversations between participants, and the physical classroom setting.

During the first three weeks of the observations, I sat in the last row of the classroom. After the first three weeks, I reached a point of data saturation (i.e., a point in which no new observations were made) (Mason, 2010). Data saturation represents a point in the data collection and analysis process where "more data does not necessarily lead to more information" (Mason, 2010). To invite opportunities for new data to be collected, I switched my location within the room during observations. For the next two weeks of observations, I rotated between the front and back of the room, as well as the sides of the room. At this point, I reached a second point of saturation, as I was observing the same types of interactions and engagement as in previous weeks. Given that there were only two weeks left in the course, I decided to continue my observations in case new interactions took place prior to the final exam. A total of 12 observations were completed.

Instructor Interview

The instructor interview was conducted using a semi-structured interview protocol. Semi-structured interviews involve using a set of flexible, open-ended questions that guide the interview but do not require particular responses from participants (Merriam & Tisdell, 2016). Semi-structured interviews assume that participants define the world in unique ways and hold space for participants to share their experiences and how they view them (Merriam & Tisdell, 2016). Therefore, the instructor's semi- structured interview allowed the instructor to share their teaching practices within the classroom and their experiences teaching Statics with LAs.

The instructor interview occurred two weeks after the course final exam. At this point, the instructor had already submitted grades and was at the start of the second mini-term, where they were teaching a new course. The interview was 30-45 minutes in duration. Some of the questions asked during this interview included:

1. When did you start teaching Statics?
2. When did you start incorporating LAs into your course?
3. Could you describe a typical day in the classroom with LAs?
4. What strategies/techniques/approaches do you use to help gauge your students' learning?
5. What are the most challenging concepts for students, and why?
6. What advice would you give to an instructor teaching Statics for the first time?
7. What has been your most memorable experience teaching Statics?

For the full interview protocol, please refer to Appendix E.

LA Focus Group Interview

The LA focus group interview was conducted using a semi-structured interview protocol. Focus group interviews are interviews conducted with a group of people who have knowledge and experience with the topic of interest for the study (Merriam & Tisdell, 2016). Given that social capital (i.e., social network and norms) exists within the interactions of groups, asking a group of people a series of questions, rather than an individual, may generate data that is richer than data resulting from other data sources, such as surveys (Choy, 2014; Dudwick et al., 2006; Merriam & Tisdell, 2016). Therefore, these focus group interviews and the semi-structured nature of these interviews created an opportunity to gather deep insights into the LAs' experiences.

The LA focus group interview occurred a week after the course final exam. I recruited the LAs after one of the class meetings, and both of the LAs of the course chose to participate in the interview. A gift card incentive was provided to both of the LAs for their participation. The focus group interview was 30-45 minutes in duration, allowing LAs to share their experiences based on the following questions:

1. Could you share a bit about how and why you became a Statics LA?
2. Could you describe a typical day in the Classroom with LAs?
3. What were your expectations coming into the Statics classroom as a student?
4. What advice would you give new LAs teaching Statics for the first time?
5. What has been your most memorable experience being an LA for Statics?
6. If you could restructure how LAs are used in Statics, what would the course look like?

For the full interview protocol, please refer to Appendix F.

Student Interviews

The student interviews occurred a week after the final exam after the students had received their final grades. The students were recruited through a Canvas Announcement sent by the instructor, and two students chose to participate. In this announcement, the students were informed of the study and were asked to contact me if they would like to participate in the interview. A gift card incentive was provided to those who chose to participate.

The interviews were semi-structured, 30-45 minutes in duration, and held space for students to discuss their experiences in Statics. Some of the questions asked during these interviews included:

1. How has your experience in Statics been so far?
2. What were your expectations coming into Statics?
3. Could you describe a typical day within a Statics class?
4. How does your experience compare to other courses that you are taking or have taken?
5. What topics in Statics have you found to be most difficult so far?
6. If you could restructure the way your Statics course is taught, what would it look like?
7. What is your favorite part of Statics?

For the full interview protocol, please refer to Appendix G.

Data Analysis

The data analysis process, as a whole, began with the deductive analysis of the observations using the Teaching Discourse Moves (TDM) framework, and as appropriate, the inductive analysis of the observations allows for emerging themes specific to a Statics course. Finally, the interviews were deductively and inductively analyzed using the findings of the observations and the TDM framework. Figure 1 provides a look into the data analysis process.

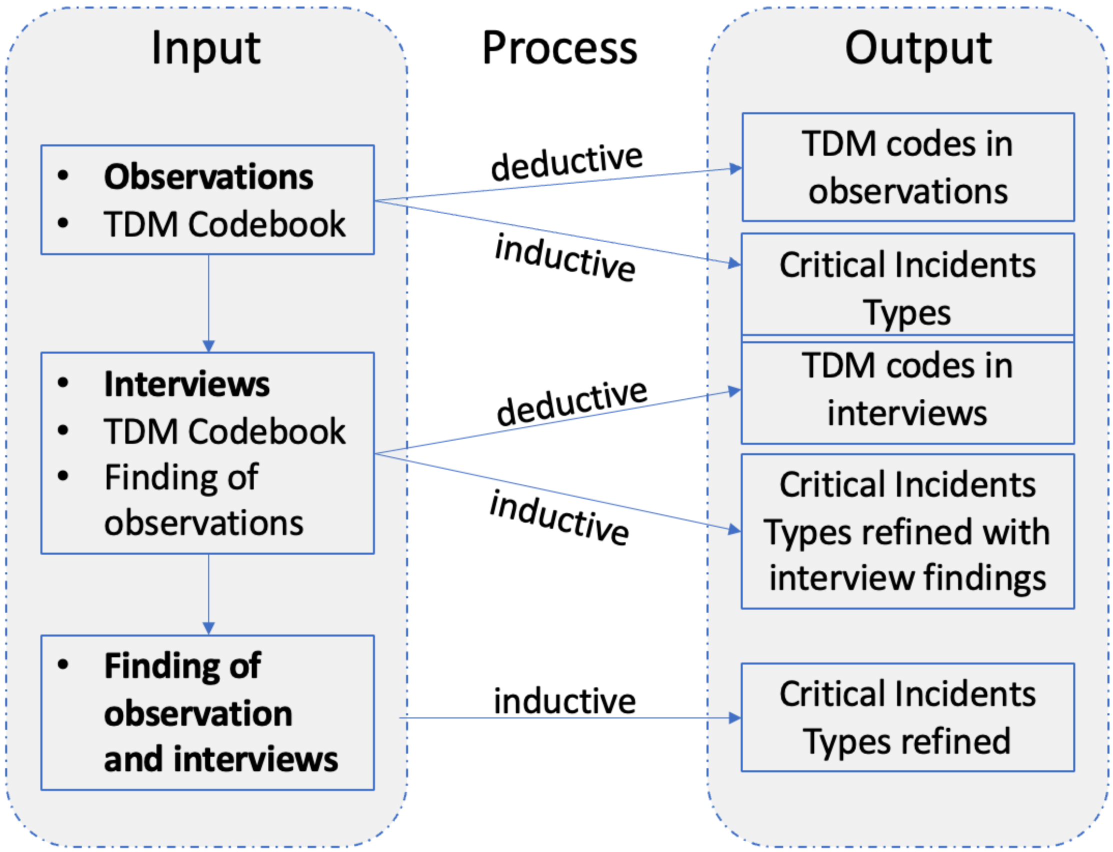

Figure 1: Data Analysis Process

Deductive and Inducting Coding Procedures

The data was analyzed using a blend of deductive and inductive coding methods. The purpose of the deductive coding method was to explore how a Statics classroom with LAs is enacted and how the interaction between students and LAs/instructors varies. Deductive coding relies on a predetermined set of categories to analyze the data (Fereday & Muir-Cochrane, 2006). For this, I leveraged Kranzfelder 's version of Teaching

Discourse Moves (TDM) framework to identify categories that describe the teaching moves the instructors and LAs used to mediate discussion and interact with students within the classroom.

The inductive coding approach allowed themes not currently captured by the framework to emerge from the data (Fereday & Muir-Cochrane, 2006). In particular, I used the modified constant comparison method to create categories that describe emerging findings (i.e., those that are not captured in the TDM framework) and then to either expand existing categories and specify one or more new categories (Charmaz, 2014). This data analysis process began while I deductively coded the data. If the moments in which the codes of the TDM framework did not entirely fit were frequent and unique, a new category was created, or a previous category was expanded. Then, the resulting emerging categories were further examined by consulting the literature and in discussions with 4 critical peer de-briefers. Critical peer de-briefers are peer researchers with perspectives that are different from my own and would help me uncover any potential biases in my work (Creswell & Miller, 2000).

An example of this new category development is the *Instructional team noticing class environment and student actions* code. This category was added because the TDM codebook did not capture moments where the instructional team noticed the classroom environment and student actions. An example of this is the following:

> <u>Instructor:</u> *"I know there is a group that is answering all the questions, but if there is somebody that is lost, please let me know, I don't mind catching up, so please does anybody have any questions?"*

Other categories that emerged are described in the following section.

Analysis of Observations

To ground my understanding of the experiences and perceptions of the instructional team and the students, I began the analysis with the observations, in other words, what happened in the classroom on a daily basis. First, I split up the observations into five different sections based on the flow of the content within the course. Specifically, I considered the topics in each chapter, moments in which there was a significant shift in topics, and the number of observations each section had. While the perfect split could not be found, a split in which most of these considerations could be taken into account was done. Detail on what each section contained and the number of observation notes pertaining to these sections can be found in Table 2.

Table 2: Sections of Observations

Section Number	Chapters	Number of Observations
Section 1	Ch.1 Fundamentals of Statics Ch.2 Force Vectors	3
Section 2	Ch.3 Equilibrium of Particles Ch.4 Force System Resultants	4
Section 3	Ch.5 Equilibrium of Rigid Body Ch.6 Structural Analysis	4
Section 4	Ch.7 Internal Forces Ch.8 Friction	2
Section 5	Ch.9 Center of Gravity and Centroid Ch.10 Moment of Inertia	1

With these observation sections, I focused my analysis on significant moments within the class sessions. In particular, I adapted an approach from critical incident analysis techniques (Flanagan, 1954) to capture moments when something occurred that would have immediate or long-term consequences on the students or the flow of the course. Critical incidents are formally defined as an observed scenario in which the impact, intentions, or significance of the scenario can be seen and can be described as a significant event that has immediate or long-term consequences (Flanagan, 1954). Such critical incident types were identified across all five sections, and the resulting critical incident types were named and refined within each phase of the analysis process. The following (Table 3) details the critical incident types and their definitions. Examples of these critical incident types can be found in Appendix H.

Table 3: Critical Incident Types

Critical Incident Type	Definition
Framing expectation of course content	Moments in which the instructional team shared the importance of what they are learning in Statics, and how it applies to engineering applications and content they will see in future courses. These incidents were prominently observed when the instructor shared real-world examples during the lecture portion of the course.
Framing expectations of course structure and content delivery	Moments in which the instructional team express to the students what the students will be experiencing throughout the course. These incidents were observed in the actions that instructors and LAs consistently made throughout the course, the course structure, or expectations that are explicitly told to the students of what they would be doing throughout the course, etc.
Instructors' expectations of students	Moments in which the instructor sets expectations of their students such as expectations of their prior knowledge.
Student acting on expectations set by instructional team	Moments in which the students acted on the expectations set by the instructional team, such as asking questions in class and interrupting the class for clarifications, as the instructional team encouraged throughout the course.
Instructional team's views on the course	Moments in which the instructional team shared their views on the course and the components they found valuable. These incidents were observed when the instructor voiced their thoughts on the value of certain aspects of the course such as the LA sessions and online videos.
Instructional team noticing class environment and student actions	Moments in which the instructional team noticed events that were occurring within their classroom, such as changes in attendance, changes in interaction with the students, and areas in which students might be struggling.
Instructional teams tailored interaction with students	Moments in which the instructor or LAs were tailoring their interaction with students. One prominent example of this was how the LAs and instructors explained problems in Spanish to students that were more comfortable speaking Spanish. Other moments included the LAs explaining the same concept in different ways until the student understood the problem.
Instructors' encouragement of student involvement in lecture	Moments in which the instructor encouraged students to become more engaged in the lecture portion of the course. These incidents included moments where the instructor encouraged students to perform calculations or give her the next steps to the problem.
Role differences between LAs and Instructor	Moments in which differences in the roles of the instructional team are salient, such as whom the students approach for particular questions or the types of knowledge an LA or instructor focuses on developing.
Instructor requesting feedback on the course	Moments in which the instructor requested feedback on the course through surveys or verbal discussions in class.

Interview Analysis

While the observations served as the foundation for developing an understanding of the interactions among students, the instructor, and LAs, the interviews brought depth and richness to the results as they answered “why” questions or provided additional detail on the critical incidents. The interviews were coded based on: 1) findings of the observations, 2) the TDM framework, and 3) emergent themes related to the interactions as well as the incident types themselves. This approach allowed me to bring the student, LA, and instructor perspectives into the findings of the observations as well as to collect novel information based on what the participants shared during the interviews. After this, the interviews were coded with the TDM codes, as well as the emergent themes found in the observations. Coding the interviews with the emergent themes found in the observations allowed for the refinement of the emergent themes that were found during the inductive coding of the observations.

With the analysis of the observations and the interviews, I revisited the research questions and categorized the interactions types (Research Question 1) based on who was involved in the interaction (i.e., LA-student interactions, instructor-student interactions). For Research Question 2, the impacts of these interactions were defined based on the impacts they had on students and the continued lack of engagement and difficulties felt by the instructor, LAs, and students.

V. LIMITATIONS

To explore how a Statics classroom with LAs is enacted and how the interaction between students and LAs/instructors varies, a qualitative case study of a Statics course with LAs was conducted. The most commonly cited limitation of case studies is the lack of generalizability of the findings (Yin, 1989). However, Yin states that a “case study does not represent a ‘sample,’ and the investigators' goal is to expand and generalize theories and not provide statistical generalizations” (Yin, 1989, pg. 10). In terms of the context of this study, this case study conducted does not aim to provide statistical descriptions of a Statics classroom with LAs. Instead, it aims to provide a detailed, in-depth look at the day-to-day interactions occurring within a Statics course with LAs, specifically through the use of a guiding framework. As such, I used the Teaching Discourse Moves framework to guide the data analysis of this study and examine how a Statics classroom with LAs is being enacted and what interactions are occurring within the classroom.

As stated earlier, this case study included in-class observations. Data collected from observations represent a direct encounter with the phenomenon under study instead of secondhand narratives of the phenomenon obtained through interviews and surveys (Merriam & Tisdell, 2016). However, Merriam and Tisdell (2016) state that observers see things directly and use their knowledge and expertise in interpreting what they observe rather than relying on accounts from the participants themselves, allowing for the implicit bias of the observer to potentially impact the study (Merriam & Tisdell, 2016). As stated in my positionality statement, I used techniques such as audit trails and memoing to record any decisions I made and why they were made throughout the data collection and data analysis process, helping me keep track of and reduce potential biases. These audit trails and memos were shared with critical peer de-briefers, and their help was enlisted during the data analysis process, which helped bring perspectives that are unlike my own and helped uncover any potential biases within my work.

Another data source within this study were focus-group interviews. The LA focus group interview provided rich may not be easily gathered within surveys or individual interviews. Hennink states that “perhaps the most unique characteristic of focus group interviews is the interactive discussion through which data are generated, [where] participants share their views, hear the views of others, and perhaps refine their own views in light of what they have heard” (Hennink, 2014, pg. 2-3). However, focus group interviews typically comprise of a small sample size. Within this study, there was only one focus group comprised of the only two LAs within the course. These sample size limitations may limit transferability to other Statics courses. Another limitation of focus group interviews is that some participants may not feel comfortable sharing their experiences to their fullest extent to a group that they most likely do not personally know well (Merriam & Tisdell, 2016). This may not allow for their full stories and experiences to be heard. To mitigate this and make the participants more comfortable during these interviews, the focus group interview questions were refined through pilot focus group interviews with critical peer de-briefers to ensure that the questions did not probe too much into personal topics that participants may not be comfortable sharing with others.

The interviews conducted with the student and the instructor were semi-structured. One of the advantages of using semi-structured interviews is that they assume that each participant defines the world and their experiences in unique ways, and through the flexible, open-ended questions that are inherent to semi-structured interviews, participants are allowed to share their experiences as they view them (Merriam & Tisdell, 2016). However, the quality of the interviews is often determined by how the interview is conducted, especially ensuring that the interviewee feels comfortable in sharing their experiences with the researcher. To ensure that the participants were comfortable throughout the whole interview, a pilot interview was conducted with peer researchers, allowing for the interview questions to be refined based on their experience participating in the interviews. Areas that may have caused tension during the interviews or probed deeper than needed for this study were refined or removed.

As previously discussed, this study used four data sources to explore how a Statics classroom with LAs is enacted and how the interaction between students and LAs/instructors varies. These data sources carry with them perspectives of the in-class observer, the instructor, the LAs, and the student, all of which have their own set of limitations. However, multiple data sources allow for triangulation to occur, which is defined as using a combination of methodologies to study the same phenomenon (Jick, 1979; Merriam & Tisdell, 2016). Merriam and Tisdell (2016) state that triangulation is a powerful approach for increasing the credibility or internal validity of a study (Merriam & Tisdell, 2016). Therefore, using multiple data courses helped mitigate concerns about the credibility of the results seen from all data sources separately.

A final limitation of this study concerns the length of the course selected for the study. This course took place within a 7-week time period when traditional Statics courses are typically 14-weeks long at EPU. The fast pace of the course could have impacted how the students, LAs, and instructors perceived their experiences in the course. This limitation may not allow for the transferability of results to other courses that typically take place in a 14-week period, specifically in areas that may have been a result of time constraints.

VI. RESULTS

The interactions that occurred within the Statics course, as well as their impacts on the instructor, students, and LAs are detailed in this section. The participants of the study will be referred to using their pseudonyms. This section will: 1) describe the types of instructor-student and LA-student interactions that took place, 2) discuss some of the impacts of these interactions, 3) outline how the LAs remained untapped resources for many students in the course, and 4) detail some of the ongoing challenges of Statics. The following (Table 4) details whether the critical incident was student- or instructor-centered, who primarily began the interaction, and what part of the course they took place in (i.e., lecture, LA session, or LA tutoring session).

Table 4: Student- and Instructor- Centered Critical Incident Types

Critical Incident Type	Form	Who	In Lecture	In-class LA Sessions	LA Tutoring Session
Framing expectation of course content	Instructor-centered	Instructor LAs	✓	✓	
Framing expectations of course structure and content delivery	Instructor-centered	Instructor LAs	✓	✓	
Instructors' expectations of students	Instructor-centered	Instructor	✓	✓	
Student acting on expectations set by instructional team	Student-centered	Student	✓	✓	
Instructional team's views on the course	Instructor-centered	Instructor LAs	✓	✓	
Instructional team noticing class environment and student actions	Student-centered	Instructor LAs	✓	✓	
Instructional teams tailored interaction with students	Student-centered	Instructor LAs	✓	✓	✓
Instructors' encouragement of student involvement in lecture	Student-centered	Instructor	✓		
Role differences between LAs and Instructor	Student-centered	Instructor LAs	✓	✓	✓
Instructor requesting feedback on the course	Student-centered	Instructor	✓		

Instructor-Student Interactions

Professor Maria's interactions with the students were mostly observed in the lecture portion of the course. In the words of Lucy, a student of the course, the lecture portion of the course could be described as the following:

"The lecture portion was really good. I think she gives very good analogies and she gives very good comparisons. She's always showing pictures… I was like, "Wow, so this is what statics is used for?" It makes you think… It makes you more interested. It makes you want to keep learning about it. […] [The problem-solving section during the lecture was] definitely very helpful… So the fact that she breaks down each question and shows us different types of questions relating to that chapter and how to answer the questions, that is the biggest help ever… So at least we kind of had those problems in our head when the worksheets came, so if we had questions to ask LAs, it wasn't anything out of the world."

During the observations of the lecture, Professor Maria spent most of the time relaying course information about the course and delivering content, with many of the interactions containing teacher-centered discourse moves (e.g., lecturing) as compared with student-centered discourse moves (e.g., having students explain the next steps in a problem). However, instructor-student interactions containing student-centered discourse moves were seen in the LA sessions, where Professor Maria engaged with students one-on-one. One of the prominent examples of Professor Maria relaying course information and content to the students during the lecture was seen in the observations at the beginning of each class session. Professor Maria projected the PowerPoint notes of the chapter on the board, but rather than go through the PowerPoint slide by slide, she wrote out the important information from the chapter on the board. During the class observations, she described this as the "necessary theory" for the chapter that she wanted to emphasize. During this, she also took time to link the new information given in the current chapter with information students had learned in previous chapters. She did so in a generative manner, where she asked students to recall the information from previous chapters, which encouraged students to associate past topics with current topics.

When working through the examples in the lecture, Professor Maria was consistently checking in with students to gauge their understanding of the content as well as guiding them through how they might approach the problem. The checking-in was done throughout the examples with questions as simple as “are you all understanding?” and “so far, so good?”. The guidance was provided by asking students to recall how to proceed with the problem, giving the students hints to the next steps of the problem, and asking students to explain their reasoning when it was not clear. An example of this is the following, where students are working through a problem on vectors:

> *Professor Maria: “What will be the direction of vector B? What is the magnitude of vector B?... What do I have to do now”*
> *A student responds that they have to find vector AB*
> *While finding vector AB, Professor Maria asks the students for every step in between, such as what are the i, j, k components and what are their magnitudes*
> *Professor Maria checks in with the students: “so far, so good?”*

Moments like this and the positive impact they had on the students were discussed by the students during their interviews and will be further discussed in the upcoming sections.

Furthermore, Professor Maria sought to ensure that she was reaching everyone in the class. There were moments when Professor Maria noticed the classroom environment and students’ actions and made sure to ask those who did not typically speak up if they had any questions. An example of this is the following:

Professor Maria: "I know there is a group that is answering all the questions, but if there is somebody that is lost, please let me know, I don't mind catching up, so please does anybody have any questions?"

Professor Maria also consistently tried to encourage student involvement throughout the lecture portion of the course. She did this by urging students to perform calculations and answer questions about the next step of the problem. She also encouraged her students to contextualize what they were learning and understand how Statics would apply to a given real-world problem. A prime example of this is the following:

Referring to a diagram containing a chain with a resulting load at one end, in the direction of the chain

Professor Maria: "Why do we want to calculate that resultant force?"

Student: "to choose the proper chain"

Professor Maria continues explaining the concept using the students' idea

In this example, we see Professor Maria asking the students why it is important to calculate the resultant force in the direction of the chain. These generative questions gave the students the opportunity to think past simply calculating the force and understand why it is necessary. Moments like these resonated with students and are discussed in future sections.

Overall, Professor Maria's interactions with the students during the lecture were both student- and teacher-centered, with most of the interactions consisting of relaying course content, checking in with the student, answering questions, guiding students through problems, and encouraging student involvement throughout the course. However, the LA sessions provided Professor Maria the opportunity to engage with individual students more directly than she would have been able to had there not been LA sessions within the classroom. She was also able to personalize her interactions with the students during the LA sessions. Specifically, Professor Maria was able to go around answering student questions and as well as approach students she noticed might need some help. She is also able to gather formative feedback from her students through these sessions. In the interview, Professor Maria, the instructor, explains that the LA session

> "*is not only for [the students] to get help, but I go around the class, and I see if they're able to draw free body diagrams, and then I say, "Well, gosh, these people doesn't know anything still," but I know that only when I see them working in the class or when I assess that in the exams, but then it's too late. […] Right now, I see their work from the very first […] So I see how bad they are struggling.*"

Furthermore, the instructor personalized interactions with the students by being able to explain concepts in Spanish to students who were more comfortable with the Spanish language. This was essential in breaking down language barriers for Spanish speakers in the course, which may not have occurred had the LA sessions not been implemented.

LA-Student Interactions

Unlike Professor Maria's interactions with the students, the LAs' interactions with the students were all student-centered, with all of the interactions consisting of answering students' questions, checking in with the students, guiding students through the problem with questions, and dedicating time to explaining concepts more deeply than what was covered in the lecture. They were also able to engage more frequently with the students through their out-of-class LA tutoring sessions that occurred for 1 hour, 3 times a week. In addition, the LAs personalized their interactions with the students, which positively impacted the students.

In the very first LA sessions, the LAs clearly stated that during the 45-minute LA sessions, they would be walking around answering any questions the students may have, they just needed to raise their hands, and they would be there. This pattern of answering students' questions continued throughout the course, but in addition to answering questions, the LAs checked in on the students and asked them how they were progressing through the worksheet they were completing and if they needed any help. During the sessions, I observed the LAs looking over the shoulders of students and seeing the work they were doing on their worksheets. Sometimes the LAs asked the student if they needed any help, and other times, they moved on to the next student. This pattern continued throughout the course and in the interviews with the LAs. The LAs stated that they have students that

> *"just stare at the paper, and they don't know how to start. For those, [the LAs] need to probably take a little bit more time [and they ask] "how would you approach the problem? What are they asking you to find," and that kind of stuff, and maybe try to guide them a little more… because they're, [...] more lost. No offense because it happens, but they need more help."*

Many of these incidents seemed to initiate conversations with students who were otherwise silent throughout the class.

The LA session also allowed the LAs to further explain topics that the instructor may not have had time to fully explain in the lecture. This further clarification of previous topics was prominent in moments where the LAs would spend extra time explaining prior knowledge concepts to students during the LAs session, showing a clear difference in how Professor Maria and LAs address students' prior knowledge. An example of this was with students' prior knowledge of trigonometry. The LA session on the first day of the class consisted of completing a trigonometry worksheet that would help students gain a better understanding of trigonometry. This review was specifically done for the LA session, while the lecture portion covered the fundamentals of Statics, such as where it came from, why it is used, etc. During the LA session, the LAs helped students complete the worksheet and refresh their knowledge of trigonometry. Here, we see that the instructor used the LA sessions as a way to help students review prior knowledge. However, this did not seem to be enough as the LAs regularly helped students continue to strengthen their trigonometry skills throughout the course. During the LA sessions, the LAs were able to further explain these prior knowledge concepts to students who needed it, such as in the following example, which occurred in the 4th class of the semester:

> *Jessica, an LA, went up to a group and asked them, "Do you have any questions?"*
>
> *Student: "How do you find that angle?"*
>
> *Jessica: "Do you remember trigonometry?"*
>
> *The students shook their heads no, and Jessica explained [an easy way to remember how to compute sine, cosine, and tangent of angles in a triangle] to*

them and suggested they continue to review it because they were going to use it a lot

Moments like this allowed the LAs to continue strengthening course concepts that were already covered in previous classes. Additionally, the LAs were able to personalize their interactions with the students by explaining a problem or concept in different ways until the students understood, while Professor Maria may not have been able to do this during the lecture due to time limitations. The LAs were also able to personalize their interactions with the students by explaining concepts to Spanish-speaking students who were more comfortable speaking Spanish. Catherine, an LA, mentions that "*you need to think different for every person, and you need to explain everything differently so everyone can get it.*" The LAs also recall having to realize that everyone comes from different backgrounds, and they have to adapt their teaching to them. They state that

> *"in this university, we have students from all over the world, so that same high school background I have, someone, I don't know, from China and Japan, I don't know, will not have the same [background]. So we need to take that into account as well."*

These moments and their positive impact on the students were frequently mentioned by the students during the interviews. Additionally, during the interview, the LAs recalled it being a blessing to be able to speak the language that some students were most comfortable with.

> *I think they're more comfortable speaking Spanish. I don't mind either. They know we speak Spanish, so they approach us in Spanish, so we answer in Spanish.*

They ask me in English, and I hear them in groups talking in Spanish, and I say, "Guys, if you prefer Spanish, I can also explain in Spanish. As long as you understand, I'm here for you." That's a blessing. Thank God we spoke both, and we're able to help you in both.

Moments like this can be essential in breaking down language barriers that would otherwise persist in courses that did not include LAs. These moments are also essential in supporting students' sense of belonging in the course and major, especially at a Minority Serving Institution, where a large percentage of students speak Spanish.

Furthermore, in the interviews with the LAs and Professor Maria, all three perceived that the students might be more comfortable or get along better with the LAs than they would be with the instructor alone. The LAs believed that the students were more comfortable asking them questions. As illustrated in the following quote from the Catherine:

"I think they're more comfortable asking us questions because we can answer it, I don't know, five times if they want to, and we are going to keep answering the same question until they get it. I think that with the professor, they go to the professor. They ask it maybe twice, and then it's like, "Okay. I better go back, and study, and get it myself because if I keep asking the professor, she will think that I didn't pay attention in class," or something like that. So I think they're more comfortable asking us questions"

Professor Maria also expressed that she thinks that since the LAs are closer in age to the students, they understand each other better because they have the same vocabulary, are peers to the students, and have been in the students' shoes much more recently than her.

> *"The LAs are the same age, and they took the class maybe a semester before, [the students] have a role model. I say, "Oh, if she could do it, I could do it." Because, in my case, they say, "Well, she's having 20 years doing this. That's why it's so easy." With LAs, they have a comparison that is different. I mean we have a gap in age, so maybe I don't have the same vocabulary as you guys have. Having somebody your age teaching you something is not the same as having a professor."*

Considering that the LAs are also undergraduate students, the interactions with LAs presented a smaller power distance between themselves and the students. This smaller distance potentially enabled students to engage with the instructional team more than they would have if it was an instructor-only course.

The LA-student interactions were not only present during the class but also continued during the weekly LA tutoring sessions. Although no observations took place during these sessions, as they occurred outside of class, the students that were interviewed recalled these sessions as being pivotal to their success in Statics. As described by the interviews, during these sessions, the LAs were able to further emphasize and explain concepts to students, as well as clear up any misunderstandings or questions that the students may have. These sessions allowed for the number of interactions between the LAs and students to increase for those who engaged with this resource. The impact of these LA sessions, as well as the in-class sessions, are detailed in the following section.

Impact of Interactions on Students

Impact of Interactions During Lecture

The interactions described above positively impacted the students who were engaged in those interactions. This impact is evidenced by the interviews with Lucy and Mouse, both of whom were students who actively participated in many of these interactions. While engaging in the lectures, Lucy and Mouse believed that the moments in which Professor Maria was making them think back to previous topics were a very important part of the course. *"You have to build from [the beginning] to continue on and if you're struggling to build that foundation, then later on, it's going to be more difficult."* Furthermore, they viewed the real-world examples Professor Maria used in class, as well as how she developed discussions on how Statics applied in these examples were important. Lucy recalled how

> *"[the instructor is] very good at helping us visualize stuff and just helping us understand the material at its core, not just on an academic level. More of a real-world level. So I like that. Because it's hard for people to make that connection sometimes, so the fact that she's helping us make that connection is a very big thing to me."*

They also described how Professor Maria's methodic method of going through the example problems and checking in with the students during the problem solving was helpful. Mouse explained

"She puts like all the formulas we're going to need, all the steps, step one, do your coordinate systems and step two, free body diagram and all that. So she always starts an exercise and then she goes back to the steps she had on the whiteboard. So it's always very methodic. So she has like four steps of doing it and she makes sure we understand she's going to every step on the exercise solving."

From this, it is evident that the interactions that occurred in class during the lectures positively affected these two students and contributed to their learning experience. However, it is critical to note that not all students of the course engaged in these interactions as class attendance heavily declined throughout the semester, as will be discussed in the following section.

Impacts of Interactions During In-Class LA Sessions

The students spoke highly of their interactions with the LAs during the in-class sessions. In particular, the students appreciated the opportunity to work on the problems themselves and get help in the moment they needed it.

"I like the interactions [with the LAs], I like the 45 minutes we had at the end of the class to do the worksheets and all of that. I think that's great, I think that's probably the best thing of the class because it's not just doing the exercises with your professor, its also doing it yourself. And I think the LAs of the class did a great job in those 45 minutes"(Mouse)

Lucy shared similar sentiments about the LA session.

"I never had an LA before in a class before, so the fact that they were there and the whole point of them being there is to help you, it makes you... It's kind of comforting in a way. It's like, "Okay, I might be stuck on this, but I still have help." Like it's not the end of the world type of thing."

Additionally, the LA sessions allowed the students to engage with other students within their course. Lucy stated that not only was she able to talk to the LAs and Professor Maria, but she was also able to collaborate with other students.

"Like we had, I think, two, three students in the class where they just, I guess, read statics like it was English and they were really good. They were always open to helping everybody, which I really appreciate. Those students, God bless them because... I always tell them, "You guys are angels. I hope you know this." […] So that's much appreciated. I really want to say that helped out, I'm pretty sure, the entire class, not even just me, making the class a little bit easier to understand. Knowing that we have students that are willing to help that did understand the material."

During these sessions, these two students were able to get help when they needed it as well as work together with other students. In addition, having the LAs in these sessions gave students a support network that they would not have if the LAs were not there. However, again, it is necessary to note that not all students of the course engaged in the LA as class attendance declined throughout the semester, and some students even left at the start of the LA sessions. This is discussed in the following sections.

Impacts of LA Tutoring Sessions

Both Lucy and Mouse regularly attended the LA tutoring sessions that occurred outside of class hours, and both expressed the importance of these sessions. These tutoring sessions were times the LAs set up outside of class, which were open to all students. Students were able to ask questions and work on problems with the LAs during these sessions. Lucy recalls telling her classmates that they were "sleeping," or missing out, on attending these tutoring sessions or, as she calls them, office hours:

> *"So definitely LAs. Attending office hours. I think honestly it was me and then one other student who would go to the office hours and I was like, 'Why isn't anybody coming here?' So I told the class, I told people I talked to. I'm like, 'Why don't you guys go to office hours? You guys are sleeping. You need to go to office hours.' The next thing you know, everybody came to office hours. I was like, 'Okay, cool. This is great.'*

Additionally, Lucy and Mouse recalled that the LA tutoring sessions outside of class were such a big help because they could ask the LAs as many questions as they wanted about any of the course assignments or in-class examples. Mouse described being able to ask LAs questions about homework problems he didn't understand and work through the homework problems with the help of LAs. Lucy noted how with the help of the LAs, she was able to fully understand course topics. She specifically recalled a moment where the LA helped her understand the right-hand rule that is used heavily throughout most of Statics.

“I remember the professor teaching the right hand rule and then she do something with her hand. I remember trying learning it and I'm just like, ‘I don't understand how she's doing this.’ So I told the LAs and I'm like, ‘What? What is she doing with this?’ Then she's like, ‘Just think about a clock. Okay?’ Then when she said that, I was like, ‘Why didn't nobody tell me this before? This is the most amazing trick ever.’”

These LA tutoring sessions provided an additional resource to students where they could get homework help, clear up misunderstandings, and further grasp the content of the course. Increased opportunity to interact with the LAs during the LA tutoring session positively impacted students who engaged in this resource and impacted their learning experience. Nevertheless, the LAs state that not many students attended the sessions unless it was the day before an exam, at which point they believed it was too late to reap the benefits of the tutoring sessions.

Lack of Engagement and Continued Difficulties with Statics

While the LAs gave students another way to choose how they wanted to engage in the course through the LA sessions in class and the LA tutoring sessions outside of class, there was a portion of students who chose, for reasons unknown, not to engage with these and other available resources. For example, there were times when only 25 of 50+ students in the class attended the lecture. Given the challenging and high-risk nature of Statics, the lack of engagement by students is a cause for concern and needs further exploration.

The instructional team frequently expressed their views on the aspects of the course that they found valuable and helpful for students. For example, on the third class of the semester, she noted the drop in attendance, telling the students that attending class is half of the studying they had to do for the course and asking them to continue attending class as she believed it was important for their success in the course. However, the drop in attendance persisted throughout the mini-term, something she continued to notice. Students also left prior to the beginning of the in-class LA sessions. Again, the instructor noted this drop in attendance and asked the students to stay for the LA sessions as she believed they would benefit from these sessions as well. This seemed to encourage students to stay, as many students stayed for the LA sessions after being asked. In the interview, the instructor stated that the LA sessions are beneficial to the students for the following reason:

> *"One is that students find it beneficial to be active in class, try to solve the problem themself. That's the best. That's the most important benefit, right? That students do active learning. They really have to do them themselves because they... I solve the problem. I say, "Anybody has a question? Do you understand perfectly everything?" I put the same exact problem in the worksheet, and they don't know how to do it. So they have to do the problems by themselves"*

The instructor also frequently reminded students to attend the LA tutoring sessions so that they could continue being supported in their learning outside of class. The LAs mentioned that 2-3 students consistently went to the tutoring sessions but that most students only came during the sessions before an exam, which the LAs didn't believe would help them much at that point. The LAs stated that in a previous semester, they observed the same pattern. The LAs described a previous semester that

> *"Literally, nobody was coming to tutoring hours, and we said, "Can we ask in the class why? Maybe they are not available at that time, and that's okay." Since we really like what we do and help others in the class, we said, "Okay, but let's try to make a deal. If we change the hours, will you come? What hours are you available?" We've done that too as well in the past… It worked. Yeah, when we change it, people started... Again, it was three, four, the same people that always comes, but it was something."*

Their willingness to adjust their hours to reach more students shows that they find this element of the course as beneficial for the students, but not many students are taking advantage of this resource.

Even with the implementation of LAs, students still found Statics to be incredibly difficult. Throughout the interviews, Mouse and Lucy frequently mentioned being overwhelmed with the workload of the course and the effort required to grasp the concepts of Statics well. Mouse recalled having homework and class assignments for the course due multiple times a week, with Lucy mentioning that some of the assignments would take up to four hours to complete. They were also overwhelmed by the amount of information given to them in every class meeting. While they did recognize that they had signed up for an accelerated 7-week course where *"[the instructor] has to give out the same curriculum as if it was a full semester course,"* that did not make the speed and difficulty of the course any less shocking. Lucy states, *"obviously I knew when I selected* *the course it was accelerated, but I had never taken an accelerated class and it was the only one that was being offered. So I was like, 'Yeah, sure. Why not?' Then when I got to class, I was like, "Wow, this is intense."*" Looking back on their experience in the course, both students believed that "*it's not a good idea to do it in seven weeks*."

Summary

Through the examples provided in this section, the quantity and quality of the interactions fostered by the addition of LAs in Statics can have a positive impact on the students. However, some students did not take advantage of the resources that contributed to these interactions, which could have negatively impacted their learning experience as well as negatively impacted the instructional team's experience with the course. Additionally, the results presented in this section illustrated that, although LAs have a positive effect on the students learning experience, Statics is still an incredibly challenging course, especially within a 7-week time frame.

VII. DISCUSSION AND IMPLICATIONS

Overview

Statics is a critical prerequisite course within the ME undergraduate curriculum and one of the students first engineering courses. In an effort to better support students through this challenging course, this Master's thesis explored how a Statics classroom with LAs was enacted and what interactions between students, LAs, and instructors characterized the course experience. This study also examined how those interactions impacted students' and instructional teams' experiences.

Many of the interactions between the instructional team and students involved the instructional team relaying information on and expectations of the course, checking in on the student's progress during the lecture and LA sessions, encouraging student involvement in the course, and tailoring interactions to individual students. Through these interactions and based on the perspectives shared by the LAs, instructors, and students, the results demonstrated the overall value of having LAs in Statics. However, Statics is still a challenging course for students, as evidenced by some of the experiences described in the students' interviews which indicated that more must be done to support the students in Statics. Additionally, many students did not take advantage of the resources available to them, including, for instance, the LA tutoring sessions and the LA session in class.

Benefits of LAs in Statics

Statics, like most other introductory courses at large institutions, typically has a large student enrollment. Large enrollment courses such as this make it difficult for faculty to foster high quantity and quality faculty-student interactions with the students (Cuseo, 2007; Pavlacic & Buchanan, 2017; Sloan, 2020). The high number of students can make it particularly hard for instructors to reach everyone in the course. Professor Maria experienced this first hand when trying to engage her students during the lecture portion of the course, but some students remained unresponsive. For example, she frequently made statements such as, *"I know there is a group that is answering all the questions, but if there is somebody that is lost, please let me know, I don't mind catching up, so please does anybody have any questions?"* Here, she was trying to open the lines of communication between herself and the students in class, but most times, the students did not speak up. Unlike many large enrollment courses, however, Professor Maria recruited LAs to collaborate with her as part of the instructional team.

During the mini-term, LAs created spaces for students to engage with the instructional team, especially in moments when they may not have been comfortable going to the instructor. The LAs in Statics provided a different avenue that students could use to ensure that they are getting the information they need from the course. Lucy, one of the Statics students, explained that having LAs is *"kind of comforting in a way. It's like 'Okay, I might be stuck on this, but I still have help."* Additionally, LAs had a smaller power distance between themselves and the students as compared to the power distance between the students and the instructor. These results align with other studies on Peer Learning Assistants, where students stated that they found their Peer Learning Assistants to be less intimidating than their Graduate Teaching Assistants or instructors (Pivkina, 2016). However, at times, the power distance between the instructor and students facilitated student engagement with the LAs. For example, during one of the observations, the instructor noted that students were leaving prior to the in-class LA sessions. In this instance, the instructor asked the students to stay for the LA session, as she believes that it is beneficial for them, and the students stayed. Although the students might be more comfortable approaching the LAs, the power dynamic between the students and the instructor appeared to effect how students engaged with the resources within the course

With the difficulties of Statics in mind, it is important to consider how increased interaction and numerous opportunities for students to engage with the course content can impact students' academic success and persistence to stay in engineering. Multiple studies have shown that interactions between faculty and students play an important role in college student persistence in engineering, their engagement with the course content and their academic success (Laudenbach, 2020; Pavlacic & Buchanan, 2017; Wilson et al., 2020). Similar results were seen in this thesis study, where students placed significant value on the increased interaction created by the LAs in class and in out-of-class tutoring sessions. The LAs themselves recognized the value in providing these opportunities to students and reaching out to the students individually that typically do not speak up during lectures. Through these increased interactions, the LAs were able to help students reinforce students' pre-requisite knowledge, which was not something the instructor was able to do during the lecture due to the time constraints of the course. Overall, LAs, as seen in this study, can play an important role in supporting student learning in large enrollment courses in ways that a single instructor alone cannot.

LAs continue to support student learning by providing opportunities for personalized learning experiences. The Statics LAs had extended interactions with students, which allowed them to dive deeper into course content and explain things in a variety of ways until they made sense to the student. This personalized interaction was not something that could be done during the lecture portion of the course, as the instructor could not individually address the 50+ students in the course. However, during the LA sessions in-class and the LA tutoring sessions outside of class, the LAs were able to spend time learning what the students could and could not do and addressing their questions in the moment. Lucy, one of the students interviewed, recalls she could not figure out how the right-hand rule worked, but with the help of the LAs and some tips and tricks they shared with her, she was able to understand a topic that contributed to her success in the rest of the course. These findings complement the limited existing research on LAs in engineering (Wendell et al., 2019). Wendall and colleagues (2019) study of a thermodynamics course illustrated how LAs frequently noticed students' ideas and practices, such as their strong focus on equations, their understandings of the course topics, and their novice conceptions of varying concepts within thermodynamics. Through that noticing, the LAs were then able to address the particular areas of concern (Wendell et al., 2019). LAs being able to notice different aspects of student learning is one example of how the LAs are able to engage with individual students, learn their needs, and adapt to those needs to better support them.

The personalized learning experiences provided by the LAs extended beyond the Statics topics to connect to the students as people. Frequently throughout the observations, it was observed that the LAs would spend time explaining topics to students in Spanish. This type of personalization can be particularly helpful in breaking down a language barrier for students whose first language is not English. Research on English as a second language in higher education suggests that students for which English is not their first language often have lower academic achievement and more learning difficulties compared to their English-speaking peers in classes where instruction is English-based (Andrade, 2006; Salamonson et al., 2008). While some may view this language as a barrier, this personalization represented a form of assets-based instruction, where the LAs, possibly unconsciously, leveraged a student's bilingualism as an asset and chose to answer questions and review topics in Spanish as another way of "reframing" the content (Mejia et al., 2019). This type of asset-based instruction is a particularly important consideration at Minority Serving Institutions such as the one which was the research site for this study. More broadly, LAs were able to personalize their engagement by reframing content, getting to know their students, and helping break down barriers to learning in an already inherently difficult course.

Remaining Challenges in Statics and Implications for Practice

There are a variety of positive aspects of a Statics course with LAs, such as increasing faculty-student interactions, personalizing students' learning experiences, and supporting students' academic journeys through Statics. However, there are still many challenges associated with enhancing the student learning experience, increasing students' understanding of course content, and implementing LAs into the course structure.

Implications for Mechanical Engineering Departments

Throughout the interviews, the students frequently mentioned being overwhelmed with the amount of work and effort required to fully grasp concepts in Statics. They also stated that there is just an overwhelming amount of information being given to them in Statics in the limited amount of time provided in the 7-week mini-term. However, they recognized that it is not the instructors' fault as *"she has to give out the same curriculum as if it was a full semester course."* Both students acknowledged that they did sign up for an accelerated course, but in reflecting on their experience in the course, both students also suggested that *"it's not a good idea to do it seven weeks."* These reflections by the students have some implications on the impact that different course offerings have on students. For example, Lucy states that this accelerated 7-week course was the only one available to her at the time; therefore, she enrolled in the course. Had she not done so, she would have had to wait until the following semester to enroll in Statics, already setting her back a semester within the ME program. These impacts should be considered by program directors as they schedule and design the curriculum each semester. Course scheduling for full-semester courses should take into consideration the number of students that are on track to take Statics in a particular semester. This form of course scheduling can ensure that anyone who needs to take Statics is able to take Statics in their preferred course format, rather than in the only format that is available, such as in Lucy's case. Additionally, engineering programs should reflect on the use of accelerated courses for fundamental engineering courses. Studies on accelerated courses in higher education have shown that instructors and students shared concerns about the scope and timing of assessments as well as the workload for both the student and instructor (Davies, 2006; Kretovics et al., 2005; Lee & Horsfall, 2010; Scott, 2003). These studies have also suggested adjusting the course content and assessment based on the timeframe of the course (Davies, 2006; Kretovics et al., 2005; Lee & Horsfall, 2010; Scott, 2003). With these studies in mind, if an accelerated course structure is necessary, mechanical engineering departments may consider redesigning the curriculum such that it focuses on the essential skills that the students need to learn in Statics that will allow them to be successful in future courses. Redesigning the curriculum may help minimize the amount of content students have to review in 7-weeks while also ensuring that students have the necessary skills to move on to future courses.

Apart from the fast pace of the 7-week course, students continued to feel overwhelmed by the content of the course and sometimes did not fully grasp the content. From the observations, it was clear that towards the end of the semester, students were still struggling with many of the prerequisite topics needed for Statics (e.g., trigonometry), which impacted their learning of Statics concepts. Professor Maria did spend time reviewing these pre-requisite topics, but not to the level of detail that some students needed. Considering that all students come into Statics with different educational backgrounds, ME departments should consider developing mechanisms to support students with their pre-requisite knowledge prior to their entry in Statics in order to help them be better prepared for Statics.

While the results of this study showed that the LAs are making a difference in the Statics learning experience, the implementation of LAs comes with challenges, some of which have implications for LA programs in engineering departments. For example, Professor Maria expressed concerns regarding the recruitment of LAs as well as how to use LAs in the course. She noted that it is incredibly difficult to find LAs for Statics, and it is also difficult to keep current LAs for more than a few semesters as students start exploring other interests and becoming involved in research. Professor Maria also mentioned that “defining the proper way” to use LAs in Statics is hard, and getting to the current course structure has been a “slow process” that has gone through many iterations. Currently, LAs are being used widely in math and science departments across EPU; however, this broad use of LAs is not reflected within engineering departments at EPU, where only a few instructors currently use LAs. This limited number of faculty teaching with LAs in engineering can be a barrier to entry for other faculty who may be thinking about implementing LAs, since there is a small support system for faculty teaching with LAs within the engineering department.

While other universities have used LAs in fundamental engineering courses such as thermodynamics and introductory electrical engineering courses, evidence-based practices for LA implementation in Statics are limited (Orser et al., 2020; Wendell et al., 2019). For instructors like Professor Maria that are pursuing instructional change efforts that are largely understudied in their courses, there is a limited support network. Therefore, efforts to widen the number of courses in engineering departments that use LAs are essential to enable a strong support network for faculty within their fields and institution and to increase student access to LA within their courses. This study contributes to those efforts by providing faculty interested in incorporating LAs in their courses with a detailed description of how LAs have been previously used in a fundamental engineering course and how implementing LAs has impacted the students' learning experience. The results presented here may also help LA programs in engineering departments recognize the potential of using LAs in engineering courses, consider funding future implementations of LAs in their courses, and support the expansion of the LA program at EPU and other universities with small engineering specific LA programs.

Implications for Statics Instructors

Beyond the speed of the course, students often felt overwhelmed by the content of the course and sometimes did not fully grasp the content around the time it was taught. From the observations, it was clear that towards the end of the semester, students were still struggling with topics covered early in the course (e.g., trigonometry, free-body diagrams). This continued struggle with topics covered early in the course is cause for concern as many of the topics in Statics build upon one another and extend beyond the scope of the course into other courses in the ME curriculum. Research has shown that Statics is an important factor that impacts a student's academic success in other courses in the ME curriculum due to its heavy use in courses like Dynamics, Mechanics of Materials, and even design courses (Steif, 2004; Wingate et al., 2018). Therefore, while the LAs in Statics are working to address these issues, further changes must be made to ensure that students fully understand the concepts necessary to succeed in Statics and beyond.

One possible approach is to provide low-risk assessments to test students' knowledge and address those concerns in class. For example, in the Statics course under study, students completed worksheets and homework assignments. However, the first knowledge assessment that did not include the help of the instructor, LAs, or peers was the mid-term exam, which is a high-risk situation for students as it significantly impacted their grades. Until then, the students did not have low-risk knowledge assessments that they completed on their own. Studies on non-evaluative formative assessments, such as open-ended, process-focused assessments, have shown that they can be used to reveal students' progress towards a particular learning goal, their thought processes, as well as any misconceptions they might have (Supovitz, 2012; Trumbull & Lash, 2013). One way to implement low-risk assessments in Statics courses with LAs may be to allow LAs to review the assessments. Considering that LAs have a smaller power distance between themselves and the students, and they do not grade important assignments or are not responsible for the student's grades in the course, allowing them to review the low-risk assessments may allow students to feel less pressure when faced with these assessments. Additionally, instructors should consider being pedagogically transparent with their students about the purpose of the low-risk assessments and what it means for their learning and the course. Doing this may encourage students to put more effort into the assessments if they are able to recognize the benefits of the assessments. Providing these types of opportunities may help students build confidence in their skills, as well as help them identify concepts that they need to review. Additionally, these formative assessments can provide the instructor with information on how their students are doing and what concepts may need to be reinforced.

Making adjustments to the course based on how the students are progressing is an important part of ensuring students are retaining and reinforcing course concepts (Robertson et al., 2016). As mentioned in the methods section early on in this thesis, after the first three weeks of the semester and right before the students' mid-term exam, I reached a point of data saturation. At this point, I noticed many of the same interactions in each class, which may indicate that the course is not evolving with the student's needs in a manner that could be readily observed in the observation. Furthermore, during the interviews with the LAs and instructors, when asked how they were making changes to the course based on the students’ needs, the changes focused on those that would impact future courses. For example, the LAs recall working alongside the instructor to change the worksheets for students in future courses. These forms of change benefit future students but exclude the students who triggered the change (Beran & Rokosh, 2009; Williams & Ceci, 1997). Using formative assessments, a process by which instructors gather feedback from their students multiple times throughout the semester can help address concerns that current students have when they need it most (Trumbull & Lash, 2013). Implementing formative assessments regularly can reveal student difficulties and increase the instructors understanding of the student experience as the course progresses, providing opportunities for instructors to intervene when problems arise (Trumbull &

Lash, 2013). As previously mentioned, research demonstrates that LAs can discern students' novice conceptions of and difficulties with course content and gather insights on student thinking (Wendell et al., 2019). Therefore, instructors can leverage the LAs to gather insights from students on their progress and challenges as well as overall formative feedback which can be used to implement in-the-moment changes to the course.

Considering the lack of student engagement with the resources that LAs provide, such as the out-of-class tutoring sessions, instructors should consider ways of incentivizing students to attend these sessions. For example, the instructor may allow students to gain extra credit by attending 1 in every 5 sessions available. This approach may help bring down barriers to entry for some students by encouraging students to attend and allowing them to recognize the benefits of the sessions.

Implications for LAs

The findings of this study show the positive impact interactions with LAs have on the students that engage with them in and outside of class, which has implications for LAs themselves. The results indicated that students that attended the out-of-class LA tutoring session benefited greatly from the help of the LAs. However, as both the students and LAs mentioned, not many of the students attended these sessions. The LAs mentioned that in a previous Statics semester, where they experienced a similar lack of engagement, and they decided to ask the students what times might work best for the sessions. Based on the conversations with the students, the LAs adjusted their schedules, and more students began to show up for the sessions, but still not as many as they wished. Considering that Statics is typically a large enrollment course, it is not surprising that not everyone's schedules align. To provide students with more opportunities to engage with the LAs when they are unable to attend the dedicated office hours, LAs should consider providing students with a way to communicate with LAs outside of class. This option may give students the opportunity to ask quick questions or find a time in the week to meet with the LAs if they are unable to attend the regular tutoring hours. Additionally, given the comments by all participants, the students seemed to be more comfortable speaking to the LAs and may be able to encourage students to engage more with the resources available to them (e.g., LA tutoring sessions).

Implications for Research

While the TDM framework was detailed, easy to use, and adaptable to the course under study, there were instances in which I had to adapt how the framework was used, which has implications for researchers who may consider using this framework. Kranzfelder and colleagues' TDM framework was created for its use in classroom observation protocols. As such, I faced difficulties implementing the framework in the analysis of the interviews due to how the interviews delved into the personal experiences of the participants rather than the actions that were being taken by the instructional team in the course. Researchers should take this into consideration when considering the use of Kranzfelder and colleagues' Teaching Discourse Moves framework for data collected outside of classroom observations.

This study provided valuable information regarding the types of interactions prevalent in a Statics class with LAs and the impacts of these interactions. Categorizing these interactions contributed to an expansion of Kranzfelder and colleagues' Teaching Discourse Moves framework by further detailing parts of the interactions that were not previously defined within the framework (see Appendix H), such as the participants' perceptions of these interactions (Kranzfelder et al., 2019). This expansion also detailed aspects that were uniquely seen in an engineering Statics course as well as engineering classrooms with LAs. The expanded framework can be used by engineering education researchers to further understand the types of interactions that impact student learning, which is crucial in developing ways to foster these interactions within engineering classrooms.

Further implications for Statics studies in regard to their research designs exist. In this study, observations and interviews were used to examine the statics learning environment. Without the interviews, many of the details, particularly those concerning the impact the course has on students, instructors, and LAs, would not have been known. Future Statics studies should consider implementing interviews with students, instructors, and LAs to ensure that the stakeholder perspectives are heard in research designs for Statics studies. Their perspective adds a level of important details not achievable by observations alone. Researchers should also consider observing the instructor/LA meeting and tutoring session.

Finally, this study filled a gap in multiple areas of engineering education research. More specifically, it investigated the use and impact of LAs in Statics and investigated the impact faculty-student interactions have on students. Through this study, it is evident that Statics is more than just a course; it is an environment where the interactions between the students and the instructional team, as well as how and how often those interactions happen, impact a students' learning experience in the course. Therefore, this thesis serves as a foundation for studies by providing a holistic view of a Statics classroom that include the impact of the course content and the environment on a student's learning experience.

VIII. CONCLUSION AND FUTURE WORK

Overview of the Study

Statics can strongly impact an engineering student's academic success and can act as a barrier course that "weeds out" individuals from the engineering field. Recent efforts at EPU have been made to support the student learning experience in Statics by integrating LAs into the instructional team. One of the most important roles LAs play in the classroom is supporting educational transformation toward active learning, student-centered designs, which help enhance their peers' learning experience (*LAA | About GPEs*, n.d.). Given the benefits of LAs described in the literature and the importance of Statics in an ME student's undergraduate career, the purpose of this Master's thesis was to explore the enactment of a Statics classroom with LAs, the interactions that characterize it, and the impact it has on the students and instructional teams experience with the course. To do so, a qualitative case study of a Statics course with LAs was conducted, which included 4 data sources: 1) class observations, 2) instructor interview, 3) LA focus group interview, and 4) student interviews. This case study design allowed for a detailed and rich description of a single semester of a Statics course to be collected from varying perspectives. Through the use of qualitative data sources, this thesis provided answers to the following research questions:

1. What type of interactions characterize a Statics classroom with an instructional team that includes a faculty member and LAs?

2. How do the course interactions impact students' and the instructional team's perceptions about how they individually experience the course?

To analyze the data, Kranzfleder and colleagues Teaching Discourse Moves framework was leveraged, using a blend of deductive and inductive coding methods TDMs are defined as tools that instructors use to form and mediate classroom discussions and interactions with students. Kranzfelder and colleagues' TDM framework was leveraged throughout the deductive coding process of the data, while the inductive coding approach allowed additional emerging themes to be captured, specifically using a modified constant comparison method.

This in-depth qualitative study illustrated the day-to-day in-class interactions among faculty, LAs, and students. Many of the interactions involved the instructional team relaying information on and expectations of the course, checking in on the student's progress during the lecture and LA sessions, encouraging student involvement in the course, and tailoring interactions to individual students. The students interviewed truly appreciated having LAs within the course, and the overall value of LAs was noted by all the course stakeholders. However, Statics was still a very challenging course for the students, and some students did not utilize the resources LAs provided to the fullest extent. The continued struggle among the students, despite the benefits they experience from having LAs in the course, indicates that more must be done to support students in Statics. This Master's thesis is one of the first studies in engineering to provide ethnographic-level data analysis on course interactions within Statics courses. The results have implications for LA programs in engineering departments and instructors, and students, such as providing insight to support the creation of a large and sustainable LA program in engineering.

Future Work

This thesis provides a rich description of how a Statics course with LAs is enacted and what type of interactions are occurring within the classroom, as well as the impacts of these interactions. However, future work is necessary to further understand how we can better support students' learning in Statics. For example, future studies are necessary to explore how we can better support students as they transition from their first-year physics courses to Statics. Additionally, future work could explore the demographics of both the students and LAs to better understand the extent to which LAs are able to reach students from marginalized groups. Future studies could also explore why students are not engaging in the resources provided by LAs in their courses.

This study provides a very detailed look into one specific Statics course: a 7-week accelerated Statics course. However, not all Statics courses are alike, with most Statics courses taking place in a timeframe of 14 weeks. Therefore, future studies should focus on broadening the scope of the study to include 14-week courses. A broader scope may allow for additional details of a Statics course to emerge that may not have been captured in this study. Furthermore, future studies should include observations of LA and instructor weekly meetings, which could provide details on how they work together to change the classroom. These additional details could provide a basis for extending the Teaching Discourse Moves frameworks to include work within engineering-specific disciplines, as well as working with LAs, and could allow for further implementation in other engineering courses with LAs. Broadening the scope of the study may also provide additional details that could be used to create implementation guides and resources for instructors that are considering adding LAs to their Statics courses, which is crucial as this is a research area that is largely unexplored.

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APPENDICES

A. Kranzfelder and Colleagues' (2019) Teaching Discourse Moves Codebook

Codes	Code Source[a]	Code Description	Example Dialogue[b]
1. Teacher-centered: Instructor is talking about content			
Evaluating	Hardman [33], Warfa, Roehrig [34], Rasmussen, Kwon [35], Sinclair and Coulthard [36], Mehan [37], Garton [38], Chin [32]	Instructor repeats, accepts and/or rejects student's response, or acknowledges that they don't know the answer to a student's question.	Student: Then you multiply those together and get the probability by dividing the number of fertilization events. **Instructor: Total fertilization events. Okay.**
Forecasting	Current study	Instructor associates current topics to future topic.	**Instructor: You're going to do something in lab actually focused on human population and population growth.**
Linking	Current study	Instructor associates past topic to current topic.	Student: You don't have a bigger potential as well because there's more connections, there's more access to the axon terminals? **Instructor: Well, remember, we had that summation of action potentials. We had an action potential and we had the nodes and it could split off.**
Real-worlding	Current study	Instructor relates ideas to conventional knowledge, broader perspective, and instructor's or student's personal experiences.	**Instructor: Successful genotypes-look around the room. Nothing but winner in this room, right? We have all made it to reproductive age.**
Sharing	Warfa, Roehrig [34], Krussel, Edwards [39], Pimentel and McNeill [31]	Instructor shares information, answers student question, or provides instructions for finding the solution.	**Instructor: Just think of, kind of, chromatid pairs, sister chromatid paired, it's a little easier to think of the numbers.**
2. Student-centered: Instructor asks students to talk about content			
Codes	**Code Source[a]**	**Code Description**	**Example Dialogue**
Generative	Warfa, Roehrig [34], Lidar, Lundqvist [40], Criswell and Rushton [41], Chin [32]	Instructor asks student to recall facts, and basic concepts, or related information.	**Instructor: Those come together in fertilization to make a zygote, right?** Student: Yes.
Checking-in		Instructor asks student if they have a question or need clarification.	**Instructor: Does that make sense?; Do you have any questions?; How's it going?; Are we good?**
Clarifying	Herbel-Eisenmann, Steele [19], O'Connor, Michaels [23], MacDonald, Miller [42], Chin [32]	Instructor asks student to elaborate on condensed, cryptic, or inexplicit statement.	**Instructor: Can you say more about that? What do you mean by that? Can you give an example?**
Connecting	Current study	Instructor asks student to associate past topic to current topic.	**Instructor: Costs of sex that haven't been mentioned plus what we've been talking about for the last week.** Student: Is it overpopulation?
Contextualizing	Herbel-Eisenmann, Steele [19], Krussel, Edwards [39], Criswell and Rushton [41]	Instructor asks students to connect ideas to conventional knowledge, broader perspective, and their personal experiences.	**Instructor: Anyone have an example that they really want to hear about/talk about (referring to student responses to finding analogies between cell processes and common household items)?**
Representing	Current study	Instructor asks student to create a visual or mathematical representation of content.	**Instructor: Think about how you could draw that out, too.**
Constructing	Criswell and Rushton [41], NGSS Lead States [43]	Instructor asks students to build knowledge by interpreting and/or making judgments based on evidence, data, and/or model.	**Instructor: In your own words, what is your conclusion when you look at those data?**
Requesting	O'Connor, Michaels [23], Rasmussen, Kwon [35], MacDonald, Miller [42]	Instructor asks student to justify or explain their reasoning.	**Instructor: I'm liking what I see but explain it to me** (referring to student whiteboard work calculating the number of fertilization events that produce a specific offspring).
Explaining	Current study	Instructor asks student to explain reasoning to other students.	**Instructor: Can you explain your work to everybody else at your table so that they can figure that out?**
Challenging	Michaels and O'Connor [22], O'Connor, Michaels [23], O'Connor, Michaels [44]	Instructor asks student to evaluate another student's idea.	**Instructor: Cost of sex?** Student: Pregnancy. **Instructor: I acknowledge that it's a good point, and why is there a problem with calling pregnancy a cost evolutionarily?**
3. Other			
Codes	**Code Source[a]**	**Code Description**	
No content discourse	Seidel, Reggi [45]	Instructor is not talking or asking students to talk about content.	
Other	Current study	TDM not described by these codes.	

[a]Sources of the deductive codes were 23 peer-reviewed, observation-based studies of TDMs from secondary or undergraduate STEM classrooms (see reference list). The inductive codes (current study) were those that emerged from our coding of class transcripts and videos using the Strauss and Corbin [30] grounded theory approach.
[b]The instructor portion of the dialogue associated with the CDOP code is shown in bold font. The student portion of the dialogue is shown for context.

https://doi.org/10.1371/journal.pone.0219019.t002

B. IRB Approval Letter

FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To: Dr. Alexandra Strong
CC: Valerie Bracho Perez

From: Maria Melendez-Vargas, MIBA, IRB Coordinator

Date: August 19, 2021

Protocol Title: "Examining the Use of Responsive Teaching Practices and Learning Assistants to Enhance the Student Experience within Statics Classrooms"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-21-0363 **IRB Exemption Date:** 08/19/21
TOPAZ Reference #: 110694

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

MMV/em

C. Introduction to Study Script

Hello, my name is Valerie. I am a Masters Student in Mechanical engineering. Your instructor has kindly given me a few minutes to discuss my thesis and allow you to ask questions regarding the study.

Study Purpose: The purpose of this study is to examine to what extent and how instructors and LAs in Statics are practicing responsive teaching in their course, and how their students perceive these responsive teaching practices. Responsive teaching is the idea that instructors make decisions on the course in response to the needs of their students and their students' learning process.

Research Plan: I am conducting a case study of this Statics class. Case studies are typically used to gather a detailed and in-depth description of the area that is being studied through an analysis of multiple sources of information. For my master's thesis, I will use In-class observations and interviews to gather deep insights on what teaching Statics looks like and the ways that LAs and instructors support your learning. This study is purely meant to gather deep insights on what teaching in Statics looks like with LAs and is not to evaluate your performance in the classroom.

The in-class observations will be non-intrusive meaning I will not disturb the classroom environment and or your learning in any way. The interviews will be completed twice during the term and I will reach out to you via email to request your participation. Providing consent for the in-class observations does not mean that you will automatically have to complete the interviews.

Your participation is entirely voluntary. In addition, your identity, and that of any individual you mention, will be kept confidential at all times and will only be known by Dr. Strong and myself. This study has been approved by FIU's Institutional Review Board.

To Participate: If you are open to participating (i.e., allowing me to observe you and your interactions with students during class and possibly participating in the interview, I have a consent form you will need to sign. It's a simple check yes or no if you want to be part of the study and return the form. I will email a copy of the form to everyone so you can have it for your records. Whatever you decide, you may change your mind at any time, just let me know. Only my master's thesis advisor and I will know whether you choose to participate.

At this point, please take a moment to review the consent form and let me know if you have thoughts, concerns, or questions regarding the study.

D. Student Consent Form for Observations

ADULT CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Examining the Use of Responsive Teaching Practices and Learning Assistants to Enhance the Student Experience within Statics Classrooms

SUMMARY INFORMATION

Things you should know about this study:

- **<u>Purpose</u>:** The purpose of the study is two-fold: (1) to explore to what extent and how instructors and LAs are making decisions on the course in response to the needs of their students and their learning process and (2) to examine how students perceive their instructors' teaching practices.
- **<u>Procedures</u>**: If you choose to participate, you will be asked to attend and participate in class as you normally would do. In-class observations will be conducted to gather deep insights on what teaching Statics looks like and the ways that LAs and instructors support your learning.
- **<u>Duration</u>:** This will be done during every class meeting for the first 7 weeks of the term.
- **<u>Risks</u>**: There are no foreseeable risks associated with this study.
- **<u>Benefits</u>:** There are no direct benefits to you for taking part in this study.
- **<u>Alternatives</u>:** There are no known alternatives available to you other than not taking part in this study.
- **<u>Participation</u>:** Taking part in this research project is voluntary.

Please carefully read the entire document before agreeing to participate.

PURPOSE OF THE STUDY

The purpose of the study is two-fold: (1) to explore to what extent and how instructors and LAs are making decisions on the course in response to the needs of their students and their learning process and (2) to examine how students perceive their instructors' teaching practices.

NUMBER OF STUDY PARTICIPANTS

If you decide to be in this study, you will be one of 100 people in this research study.

DURATION OF THE STUDY

Your participation will involve no additional time beyond the time you spend attending class. In-class observations will take place every class meeting during the first 7 weeks of the semester

PROCEDURES

If you agree to be in the study, you will not be asked to do anything outside of what you normally do in your class.

RISKS AND/OR DISCOMFORTS

There are no foreseeable risks and/or discomforts associated with this study, beyond what is involved with daily activities such as attending class.

BENEFITS
There are no direct benefits to you for taking part in this study.

ALTERNATIVES
There are no known alternatives available to you other than not taking part in this study. Any significant new findings developed during the course of the research which may relate to your willingness to continue participation will be provided to you.

CONFIDENTIALITY
The records of this study will be kept private and will be protected to the fullest extent provided by law. Your decision to participate or not will not be shared with the course instructor. In any sort of report we might publish, we will not include any information that will make it possible to identify you. Research records will be stored securely, and only the research team will have access to the records. However, your records may be inspected by authorized University or other agents who will also keep the information confidential.

USE OF YOUR INFORMATION
Your information collected as part of the research will not be used or distributed for future research studies even if identifiers are removed.

COMPENSATION & COSTS
You will not receive payment for your participation. There are no costs to you for participating in this study.

RIGHT TO DECLINE OR WITHDRAW
Your participation in this study is voluntary. You are free to participate in the study or withdraw your consent at any time during the study. You will not lose any benefits if you decide not to participate or if you quit the study early. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this research study you may contact Valerie Bracho Perez at Florida International University, vbrac002@fiu.edu or Dr. Alexandra Strong at Florida International University astrong@fiu.edu.

IRB CONTACT INFORMATION
If you would like to talk with someone about your rights of being a subject in this research study or about ethical issues with this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT
I have read the information in this consent form and

___ agree to participate in this study.

___ do not agree to participate in this study.

I have had a chance to ask any questions I have about this study, and they have been answered for me. I understand that I will be given a copy of this form for my records.

______________________________ _________________

Signature of Participant Date

____

Printed Name of Participant

______________________________ _________________

Signature of Person Obtaining Consent Date

E. Instructor Interview Protocol

Hello, my name is Valerie. Thank you for taking the time to talk to me today, I truly appreciate you being here today. We are recording this session for data transcription purposes. This interview will only take about 30-45 minutes.

The purpose of my Master's thesis is to examine to what extent and how instructors and LAs are making decisions on the course in response to the needs of their students and their learning process. It will also examine how students perceive their instructors' teaching practices. This interview will particularly focus on your experience as an instructor in Statics

Before we begin, I just want to let you know that any identifying information discussed in this focus group interview will be kept confidential to ensure your privacy. Your participation in this study is also completely voluntary so you may withdraw from the study at any point. Today’s conversation will be audio recorded and the recording will be destroyed once it has been transcribed and cleaned of any identifiable information. At the end of this interview, you will be asked to pick a pseudonym, which is a fake name that will be used to replace your real name in anything stemming from this work. Only Dr. Strong and I will know who you are and we will maintain your confidentiality and privacy at every point of the study. Feel free to ask me any questions that may come up concerning the study before we begin.

1. When did you start teaching Statics?
    a. How was your first time teaching the course?
    b. How has the course evolved since you taught it?
    c. What sort of interactions do you have with your students in class?
    d. Could you describe how you go about making changes to the course?
    e. What has your experience been like teaching Statics this semester?
2. When did you start incorporating LAs into your course?
    a. Why did you decide to incorporate LAs into your course?

   b. What benefits have you seen from incorporating LAs?
   c. What challenges have you experienced?
3. Could you describe a typical day in the classroom with LAs?
   a. How has your course changed since you incorporated LAs into the course?
   b. How are the LAs involved in the changes you make in the course?
   c. How do you involve students in making changes to the course?
4. What strategies/techniques/approaches do you use to help gauge your students' learning?
5. What are the most challenging concepts for students, and why?
   a. What do you do during these parts of the class to gauge your students' understanding?
6. What advice would you give to an instructor teaching Statics for the first time?
7. What has been your most memorable experience teaching Statics?
8. The purpose of my Master’s thesis is to understand your experience as an instructor in Statics. Is there anything else you would like to add that would help me with my study?

F. LA Focus Group Interview Protocol

Hello, my name is Valerie. Thank you for taking the time to talk to me today, I truly appreciate you being here today. We are recording this session for data transcription purposes. This interview will only take about 30-45 minutes.

The purpose of my Master's thesis is to examine to what extent and how instructors and LAs are making decisions on the course in response to the needs of their students and their learning process. It will also examine how students perceive their instructors' teaching practices. This interview will particularly focus on your experience as an LA in Statics

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1. Could you share a bit about how and why you became a Statics LA?
   a. What do you think are some strengths of using LAs in Statics?
   b. What challenges have you experienced as an LA?

2. Could you describe a typical day in the classroom with LAs?
    a. What is your role as an LA?
    b. How do you and the instructor work together to transform the classroom?
    c. What strategies/techniques/approaches do you use to help gauge your students' learning?
3. What were your expectations coming into the Statics classroom as a student?
    a. What do you think were some of the most challenging concepts in Statics, and why?
4. What advice would you give new LAs teaching Statics for the first time?
5. What has been your most memorable experience being an LA for Statics?
6. If you could restructure how LAs are used in Statics, what would the course look like?
7. The purpose of my Master's thesis is to understand your experience as an LA in Statics. Is there anything else you would like to add that would help me with my study?

G. Student Interview Protocol

Hello, my name is Valerie. Thank you for taking the time to talk to me today, I truly appreciate you being here today. We are recording this session for data transcription purposes. This interview will only take about 30-45 minutes.

The purpose of my Master's thesis is to examine to what extent and how instructors and LAs are making decisions on the course in response to the needs of their students and their learning process. It will also examine how students perceive their instructors' teaching practices. This interview will particularly focus on your experience as a student in Statics

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1. How has your experience in Statics been so far?
2. What were your expectations coming into Statics?

3. Could you describe a typical day within a Statics class?
    a. How are your instructor and LAs trying to gauge your thoughts on the course and its content?
4. How does your experience compare to other courses that you are taking or have taken?
    a. How have the instructor or LAs shaped this experience?
5. What topics in Statics have you found to be most difficult so far?
    a. What factors have helped you overcome some of these challenges
    b. How is your instructor or LAs ensuring that your learning is progressing with the class?
6. If you could restructure the way your Statics course is taught, what would it look like?
7. What is your favorite part of Statics?
8. The purpose of my Master's thesis is to understand your experience as a student in Statics. Is there anything else you would like to add that would help me with my study?

H. Critical Incident Types

Critical Incident Type	**Definition**	**Example**
Framing expectation of course content	Moments in which the instructional team shared the importance of what they are learning in Statics, and how it applies to engineering applications and content they will see in future courses. These incidents were prominently observed when the instructor shared real-world examples during the lecture portion of the course.	When Professor Maria is going through the syllabus and class objectives on the first day of class, she went through simple concepts of statics (equilibrium, rigid body vs. particles, etc) and asked questions that allowed students to respond if they knew what each meant, if not she would briefly explain
Framing expectations of course structure and content delivery	Moments in which the instructional team express to the students what the students will be experiencing throughout the course. These incidents were observed in the actions that instructors and LAs consistently made throughout the course, the course structure, or expectations that are explicitly told to the students of what they would be	Professor Maria tells the students that the things she writes on the board are things that she wants to put emphasis on and will be needed for the rest of the class The LAs told the class that they would answer questions as the class worked individually or in groups, the students just had to raise their

	doing throughout the course, etc.	hands and they would approach them
Instructors' expectations of students	Moments in which the instructor sets expectations of their students such as expectations of their prior knowledge.	When referring to vectors, the instructor asks the students: "you studied this in calculus 3 correct?"
Student acting on expectations set by instructional team	Moments in which the students acted on the expectations set by the instructional team, such as asking questions in class and interrupting the class for clarifications, as the instructional team encouraged throughout the course.	Lucy, a student: "But I would ask any question that I could and they had an answer for me every single time and they were so patient. Honestly, I appreciate that because I tend to ask the same question a good four times."
Instructional team's views on the course	Moments in which the instructional team shared their views on the course and the components they found valuable. These incidents were observed when the instructor voiced their thoughts on the value of certain aspects of the course such as the LA sessions and online videos.	Professor Maria encourages student to stay for the LA sessions in-class as it is helpful for them.
Instructional team noticing class environment and student actions	Moments in which the instructional team noticed events that were occurring within their classroom, such as changes in attendance, changes in interaction with the students, and areas in which students might be struggling.	Professor Maria noticed a drastic drop in attendance in the course and referred to attending class as half the studying the student had to do
Instructional teams tailored interaction with students	Moments in which the instructor or LAs were tailoring their interaction with students. One prominent example of this was how the LAs and instructors explained problems in Spanish to students that were more comfortable speaking Spanish. Other moments included the LAs explaining the same concept in different ways until the student understood the problem.	LAs frequently speak Spanish to students who prefer it when assisting them

Instructors' encouragement of student involvement in lecture	Moments in which the instructor encouraged students to become more engaged in the lecture portion of the course. These incidents included moments where the instructor encouraged students to perform calculations or give her the next steps to the problem.	Professor Maria says she welcomes interruptions from students if they are not understanding and acknowledges that she talks fast and it's a fast-paced course, so interruptions are welcomed
Role differences between LAs and Instructor	Moments in which differences in the roles of the instructional team are salient, such as whom the students approach for particular questions or the types of knowledge an LA or instructor focuses on developing.	Mouse, a student: "I remember one time, it was one grade for a worksheet that it wasn't right. And [the LAs] told me, just they didn't have access to the Canvas and had to talk with the professor."
Instructor requesting feedback on the course	Moments in which the instructor requested feedback on the course through surveys or verbal discussions in class.	Professor Maria asked the students if they thought the first exam was fair and comparable to the problems they had done in-class and for homework