An Autoethnography of the Student Experience Solving an Open-Ended Statics Problem

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Using an Autoethnographic Approach to Examine the Student Experience Solving an Open-Ended Statics Problem

Abstract

This research paper examines the student perception and experience of solving open-ended modeling problems (OEMPs) through an autoethnographic account of the student-authors' personal reflections about an OEMP completed during an introductory level statics course. Currently, the student perspective is not represented in literature about engineering problem solving. This is significant as the student perspective is integral to understanding how students learn and develop an engineering mindset. By incorporating the student voice through autoethnographic techniques, this study can begin to fill this gap and provide meaningful insights about the student experience and perceived benefits surrounding an OEMP.

Autoethnography is an approach to research and writing that incorporates the researcher's personal experience in conjunction with traditional research methods. The authors believe this is an underutilized research method within engineering education research that could provide additional insights to shift teaching and learning within engineering classrooms. The student-authors reflected on their personal experience solving an OEMP by retroactively responding to several written prompts. We analyzed our responses to determine possible patterns and emerging themes about the student perception of OEMPs.

While instructors make choices about course learning objectives, many times these are primarily based on what instructors historically believe students need to know. Rarely are students given a platform to voice the meaningful knowledge they constructed after course completion. Implications for this work include providing information to instructors on how students view innovative, problem-based work and the benefits to their development as novice engineers. This study also suggests that autoethnography can serve as a valuable research method in engineering education, allowing for a direct examination of students' own experiences and perceptions.

Introduction

The student perspective provides valuable insight that can be leveraged to improve engineering curriculum and retention rates. [1], [2], [3]. The engineering curriculum at the university level serves to engage students in activities that meet university requirements, as well as satisfy the Accreditation Board for Engineering and Technology (ABET) standards [4]. These standards are designed to provide students with the proper foundation to perform and succeed in industry after graduation. Therefore, professors must prioritize these standards and requirements in shaping their courses, while also developing interactive and compelling coursework that engages students.

Frequently, qualitative surveys and interviews are used to understand students' perspectives on engineering courses [1]. Surveys and interviews can provide windows into the student experience navigating course content and can offer insight into potential improvements that may benefit students. However, many times the student voice itself is underrepresented in literature as the data collected is analyzed and interpreted through a researcher's point of view. Furthermore, surveys with pre-specified question options, such as rankings and multiple choice, tend to overlook the student voice as students are required to choose auto generated responses that provide little opportunity for them to share their original opinions on the course [1]. There is a need for research tools and studies that allow us to more deeply understand the student perspective.

In order to explore the student's perspective on engineering coursework, the student-authors have responded to a series of open-ended prompts and reflected upon their own experiences as students working through an open-ended modeling problem (OEMP) in an introductory level engineering class. Using these reflections, we will address how the student voice can provide contributions to the engineering education space, providing first-hand insight into how students learn and develop as engineers throughout OEMPs. Further, we will compare the student-authors' reflections to those of other students from surveys conducted in this same class to provide a more holistic view on the experience of completing a project of such nature.

This paper serves to answer the following questions:

(1) What are the insights and perspectives of student-researchers reflecting on their experience solving an open-ended modeling problem?

(2) How does this compare to the experience of other first- and second-year students?

Background

Autoethnography as a Method

Autoethnography is a retrospective approach to research and writing that seeks to systematically analyze and incorporate personal experience into traditional research methods [5]. Authors produce self-written, detailed, and descriptive writings of personal experience [6]. Autoethnography is often used to illustrate facets of social and cultural experience as this writing style provides a medium for authors to incorporate their personal experience into a broader social context. Typically, autoethnography authors center their reflections around one or more "epiphanies," self-claimed phenomena that are inspired or framed by an impactful event, particular state of mind, or cultural identity.

[5]. Autoethnography may be used as an empirical research methodology that encompasses the full construction of a study or as a method of doing research, which may be situated in the broader context of a mixed method study [7].

This study, while not centered around the social or cultural context of engineering problem solving, utilizes autoethnographic techniques to elicit deep reflection from both student authors about their experience while solving an OEMP. Broadly, autoethnographic methods of data collection and analysis can include reflective journaling, field notes, interviews, and video recordings; we chose to focus on reflective journaling in this study. [7]. Additionally, we borrow ideas from collaborative autoethnography, which specifically uses multiple autoethnographies from individuals of similar social locations or social experiences to triangulate upon common shared experiences while allowing for diversity of experience [6]. This allows us to compare the experience of both student-authors, allowing emerging themes to develop simultaneously among different individuals to create stronger thematic identities.

Prior engineering education research has begun to use autoethnography to unpack the social and cultural environment in engineering education, including the experience of marginalized groups in engineering, contextualizing the engineering educational culture, and conveying the experience of engineering educators [8], [9], [10].This prior research utilizes autoethnography to advance the discussion surrounding engineering culture, student retention, and improving learning from an educator's perspective. However, very few autoethnographies discuss learning from the student perspective. We explore the use of autoethnographic methods to amplify the study voice in engineering education research. The student-authors' perceptions of their first OEMP acts as the epiphany of both students' reflections, representing a significant and impactful moment of both students' engineering education.

Methodology

Analytic Approach

This qualitative study aims to explore the experiences and perceptions of students who solved an OEMP. We used tools and techniques of autoethnography and of thematic analysis. To initiate the study, the student-authors oriented ourselves to the approach of autoethnography by reading and discussing guides to autoethnographic methods, autoethnographies, and journal articles that used written narratives as the point of analysis [5], [8], [10], [11], [12].

The undergraduate student-authors wrote autoethnographic reflections about an OEMP completed during a second-year statics class to serve as the primary source of data. We utilized thematic analysis in an iterative process to identify emerging themes and nuanced ideas between both sets of reflections. To provide comparative viewpoints, we also analyzed free-response survey data from students who completed the same OEMP. Our triangulation of these data

sources enhances the credibility and depth of findings, contributing to a comprehensive understanding of varied experiences with OEMPs.

Positionality

The authors approach this study, as well as the rest of their research, with a desire to improve engineering education for students and create learning experiences that positively engage them in learning. The student-authors are undergraduate engineering students at a large, public R1 university in the northeastern United States who engage in research on engineering judgment, OEMPs, and engineering education. The first author is a second-year student studying mechanical engineering and the second author is a fourth-year student in aerospace engineering. Both student-authors completed the focal "pool lift" OEMP in their sophomore statics class and scored in the "A" range on the OEMP and in the course. The student-authors feel that the OEMP is a beneficial tool for engineering education and had a positive impact on their personal development as engineering students. The third author, an engineer and engineering education researcher, is the research advisor for the first two authors and has been researching OEMPs and engineering judgment for six years.

Study Context

The OEMP [13], [14], [15], [16], [17] is a multistage project assigned to engineering students enrolled in statics at the University at Buffalo. Statics is offered as an introductory course and typically taken during a student's first or second year in engineering study. The OEMP extends over the course of one semester and is completed in groups assigned at random. Students are tasked with weekly assignments in order to produce a model pool lift that can withstand the weight of a user in a multitude of positions. When the OEMP was first introduced, these assignments alternated each week between individual and group-based assignments, but currently the assignments are all group based. It should be noted that when the second author took the course, assignments alternated between group and individual work, whereas when the first author took the course, the project was entirely group-based.

In completing the OEMP, students are asked to make assumptions about features of the pool lift in order to produce a mathematical model representing a real-life pool lift. Figure 1 shows the pool lift diagrams provided to students in the initial prompt, and the assumptions apply to specific members of these pool lift diagrams. These assumptions pertain to the dimensions of structural members, the weight for the pool lift base, and a weight limit for the user. Students then have to prove their chosen assumptions are valid using free body diagrams and statics principles taught in class. The project asks students to conduct preliminary research regarding real pool lifts to get a feel for sizes and regulations, and encourages the exploration of different solution ideas and problem solving approaches. In the final report, students submit their functional, mathematical model of the pool lift that must specify the dimensions of each structural member, the maximum and minimum angles the pool lift can rotate, and the material and diameter of the main structural member. Aside from initial preliminary constraints, students

are given minimal guidance during the development of their pool lift to simulate what a real world engineering experience may look like.

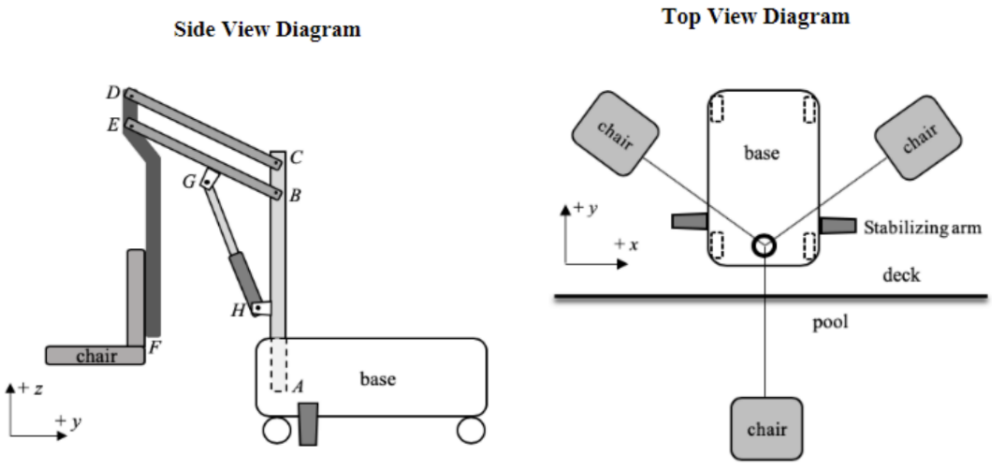

Figure 1. Pool Lift Model

Data Collection: Reflections

To facilitate the student-authors' personal reflections, the third author and a postdoctoral scholar developed a list of prompts, including inquiries about the perceived benefits and impacts of solving an OEMP on the students' learning and development, challenges faced, and the emotional experience during and after completion of the OEMP. The student-authors individually responded to the prompts, and after a week, shared the material with each other and the third author. A total of three sets of prompts were developed sequentially after reviewing the responses to the preceding set, taking place over a 12-week period. This iterative approach allowed the student-authors to gradually focus and deepen their reflections to further develop the emerging themes of their previously written material.

Moving forward and into the results section, each instance of "we" or "our" refers only to the first and second student-authors as this is our collaborative autoethnography.

Data Collection: Survey Data

For each assigned OEMP, students are surveyed at the end of the semester to give feedback to the professors and research team anonymously. Survey questions are answered on a five-point Likert scale from Strongly Disagree to Strongly Agree. Examples of these questions include statements such as "I knew what the expectations were when completing the open-ended problem" and "I enjoyed completing the open-ended problem." Students are also invited, by three open-ended questions, to give feedback to their professor and to the research team about

the OEMP. We examined 229 surveys from students who completed the pool lift problem in Fall 2021 and Fall 2022.

Data Analysis

We used thematic analysis to identify recurring patterns and themes in the student-authors' reflections. Themes were iteratively developed by each author throughout the writing process and focused on instances of commonalities, similar insights, and unique experiences in the reflections. Upon completion of the final prompt set, the research team met to compare their individual lists and collectively compile a final set of themes. Finally, specific excerpts were manually classified by the student-authors under the corresponding theme. We decided to begin with individual theming to examine the dataset from multiple angles and allow each researcher to code the data according to their individual perspective. Additionally, the validity of the identified themes was heightened through the convergence and unanimous agreement of all three authors on the final themes.

After completing the analysis on the autoethnographies, the first author examined the open-ended survey responses to provide other student views besides the overwhelmingly positive accounts by the first two authors. While much of the feedback was positive, the research team chose to focus exclusively on the negative opinions in an effort to highlight contrary ideas to the ones presented in the autoethnographic accounts and to avoid redundancy. All feedback offering a contrasting viewpoint was organized by central idea, allowing for these juxtaposed opinions to enrich the narrative and offer a nuanced understanding of the diverse perspectives within the student experience.

Limitations

Each student-author had a positive experience while completing the OEMP, resulting in the autoethnographic data only articulating a positive perspective. This forced us to rely exclusively on survey data for a comparative viewpoint to the ones presented in the student-authors' autoethnographies. This limits our ability to present a comparative viewpoint as the survey data tends to lack specific detail, leading to an analysis that may not have captured the full range of students' negative experiences.

Results

Our team identified five common themes from the autoethnographic writings: freedom, interdisciplinary connections, conceptual learning, confidence, and engineering identity/becoming an engineer. We present each theme with specific quotations from our autoethnographies alongside necessary context and analysis. Additionally, we present survey data to showcase a contrasting viewpoint to the research team's notably positive view of the OEMP.

Freedom

One common theme that surfaced throughout reflecting upon the OEMP was the notion of a newfound freedom in engineering coursework. Freedom in the context of the OEMP, according to both authors, entails the opportunity to make one's own decision on an aspect of the project without being constrained to specific approaches or equations. This theme was explored in multiple ways through our reflections, including freedom in the context of choosing a problem solving method and freedom in having an array of possible answers. This theme was expressed early on by both student-authors and became very prevalent throughout each iteration of reflection questions, presenting itself as a foundation for each of the subsequent themes. Both student-authors were prompted to define freedom in the context of the OEMP during reflection three:

> Katelyn: By freedom, I am referring to the ability to make my own decisions about approaching the problem and my own decisions about what I want my model to look like. The statics OEMP offered very little guidance or framework, so I felt that I had freedom in the sense that I could choose to base assumptions on mathematics, outside research, or even just completely arbitrary hunches.
>
> Jayden: By freedom, I mean the ability for me to make my own choices as if not to be constrained by one right answer…I did not have to worry about using a specific formula or thought process, but rather I was able to develop my own and figure out what answer felt right for myself and my group.

Each author explains that freedom, through their definition, benefits the student as it allows them to explore solving the OEMP in the way that feels right, best suiting their strengths. The OEMP's minimal direction outside the initial constraints gives students this ability to be able to reflect on their own knowledge and experiences in order to then choose how they feel most comfortable solving this problem. This idea is expressed further by both authors as they reflect on their experiences working through the OEMP and share how they used this freedom to make decisions:

> Katelyn: This meant that I could make my own independent decisions about the project but also that I could decide on my own path while solving the OEMP. I could decide in what order to work on different parts of the OEMP and what methods I wanted to use. I could choose to analyze a system however I pleased.
>
> Jayden: I feel like having freedom to explore new challenges and designs gives engineers an opportunity to think freely and develop their own thought processes. These skills are most of the time unfortunately not presented to engineers through book problems as

> many times the answer is derived from a written process. But, these skills are beneficial in the workplace when there is no guidance as to what the right answer is.

As previously mentioned, the OEMP is important as it allows students to develop problem solving processes. Both authors highlight that the freedom of choice afforded to them was instrumental in developing their problem-solving processes. Since they had the ability to choose how to solve the problem, in what order, through what lens, these students are able to explore different forms of problem solving and figure out what methods work best for them, as opposed to if this freedom wasn't recognized. Moreover, this freedom gave the student-authors the sense of an engineering mindset towards the idea that many times there is potential for a problem to have multiple solutions:

> Jayden: I liked the idea that we had the freedom to explore different design choices, all of which allowed us to learn relevant statics principles while doing so. I think this aspect is appealing in the sense that typically with homework, there is a definitive answer and process that gets you to that answer, whereas this project had no right or wrong answer, there were multiple designs that could get you to fit the criteria.

> Katelyn: Moreover, freedom was also evident in that there was a range of possible values that would create a successful model. So in that sense, a student has freedom because they are able to choose their own value, and are not relegated to a single correct answer.

Along with the freedom to explore different problem solving processes, both student researchers expressed the same freedom gave way to allowing students to have differing answers. This freedom comes with the idea that without having been given parameters within which the pool lift should be defined, there is a range of answers that a group may come to which are all considered feasible or correct.

Confidence

The OEMP had a unique impact on the confidence of each student-author. The first author felt a significant increase in her self-confidence and developed a greater trust in her decisions. The second author's self-assurance was also heightened, but to a lesser degree as compared to the first author:

> Jayden: during the OEMP it was hard to trust my decisions and judgements. I have always had a hard time believing in my abilities as an engineer unless the problem has one answer that is directly attainable through a taught method…Even though I was still very hesitant to trust my instincts after completing Statics, I feel like having completed the OEMP I have gained a sense of trust in myself and my instincts that I didn't have previously.

> Katelyn: Although I did struggle throughout the project with trusting my assumptions…The OEMP continued to develop my self-confidence because I was repeatedly forced to make assumptions…I also found it easier to begin an OEMP because I no longer have to overcome this huge self-doubt hurdle.

Here, it is clear that the students' confidence levels were affected in varying ways. The second author's confidence was somewhat boosted, but he remained relatively hesitant after the class to trust himself. The first author experienced a more tangible growth in her self-confidence and ability to trust her own decisions in a long term sense. This divergence in confidence highlights the individualized nature of the OEMP's learning process, where student growth varies based on one's unique experience while completing the problem. Despite this, both students agreed that validation from the professor provided an essential level of confidence and security in their developing models:

> Jayden: I feel the only time I actually felt confident in my decisions or judgements was when I would go to office hours and talk over my solution with [the] professor. This way I was able to confirm that what I was doing was following the right path

> Katelyn: After the first round of assumptions, [the professor] checked the numerical assumptions and our model was in the clear… Whenever we got feedback that our work was on the right track, my confidence was solidified.

In their reflections, the students emphasize the importance of the professor's confirmation and reassurance, which served as a crucial source of positive reinforcement throughout the project. The professor's validation played a pivotal role in creating a conducive learning environment to foster a greater sense of self-assuredness among the students.

Interdisciplinary Connections

During the reflection period, both student-authors independently referenced their experiences in English and social science classes to draw a comparison highlighting the novel freedom introduced by the OEMP. They discuss the liberty afforded to students when composing essays for English class and its correlation to unfamiliar freedom in an engineering context. This underscores a distinct impact of freedom, providing students the flexibility to draw upon their knowledge from other courses, particularly English and social science. While responding to a prompt about articulating the OEMP's freedom to another student, The second author writes an analogy comparing his encounter with the OEMP to his past experiences in high school English class:

> Jayden: This freedom though is like an English class, or more specifically an essay you are to write in English class. While there are still rules that you are expected to follow, and constraints applied to your project, you are given the freedom to design as you would like, just as you must stick within the constraints of the essay topic, length and page headers, but are given the freedom to write however you would like.

The transition from writing essays in English to engaging in an engineering OEMP highlights the interdisciplinary nature of learning. The second author uses his prior experience with loose essay prompts in English class to navigate the ill-defined nature of the OEMP. The first author discusses a similar idea while responding to a confidence-related prompt, again reaffirming the interconnectedness between freedom, confidence, and each student's unique reliance on interdisciplinary skills. She contrasts her assurance in making decisions during essay writing with her uncertainty in the STEM field:

> Katelyn: Prior to the statics OEMP, I had not experienced this type of problem in an engineering course. I had written essays and had confidence in my ability to make decisions related to English or social sciences, but I was very unfamiliar with freedom in a STEM context.

Here, the first author expresses a level of confidence regarding essay writing that she was initially unable to apply to engineering coursework. Her repeated exposure to essay prompts paved the way for a confident attitude that was not present when attempting the OEMP, but was eventually developed through repeated exposure to assumption-making during the project.This segment once more underscores the integration of aspects commonly found in English and social science classes that the OEMP introduces into the engineering curriculum, allowing students to integrate free-response prompts into an engineering context. Furthermore, both students discuss their reliance on research skills gained from English and social science courses while navigating the OEMP:

> Jayden: I would say in high school I learned a lot of researching skills, specifically in English class, but past that, the only other place I got to develop researching skills was in space mission design or during my internship.

> Katelyn: I've been developing research skills since high school. I took two AP English classes, where I was introduced to literature research. The OEMP helped me in applying these skills because I used several outside sources for inspiration, such as existing pool lift specs and the ADA website.

Here, both students discuss the essential transfer of research skills cultivated in English coursework to the engineering domain. The shift from essay-based research to applied

engineering research again emphasizes the interconnectedness of various academic disciplines and the adaptability of skills acquired in one area to be effectively applied in another. Moreover, each of these skills, which are not typically emphasized in engineering classes, compels students to draw upon prior experiences in which they felt confidence. This suggests a deliberate effort to boost their confidence while tackling the OEMP.

Conceptual Learning

Both student-authors discovered that the OEMP had a profound, lasting impact on their understanding of course material. This theme emerged early-on in both students' reflections and was further developed throughout the writing process. The OEMP targeted conceptual learning in several ways, but the students first discussed the impact of grappling with a difficult problem with little guidance:

> Jayden: The OEMP … allowed me to work through different statics principles on my own versus through help and forced me to explore these principles to greater lengths that otherwise I wouldn't have… my group had to iterate through the different lengths and structural piece weights giving us more time using each of the principles
>
> Katelyn: The OEMP was also a very difficult problem. I often had to grapple with the problem and spend a long time thinking through each part. This forced me to spend a lot of time working with the statics concepts, helping me to commit it to long term memory.

Here, both students discuss interacting with the statics material during the OEMP on a much deeper level than what is typically prompted by other engineering homework. The complexity of the OEMP, coupled with the need to iterate through design choices, provided ample time and space for students to thoroughly work on course concepts. These aspects of the problem fostered a more profound understanding of course material. Additionally, the vagueness of the problem definition prompted the students to apply a wide range of statics concepts. Both students discuss the positive impact of the OEMP on their cumulative understanding of course material:

> Jayden: … book problems are only serving as practice or reiteration of the general principles that are taught in that class. And at that, most of the time they are broken down very specifically to target each individual concept or idea taught separately… The OEMP shows students that in the real world, the solution to a problem won't be directly taught to them right before that problem is given to them. It also exposes them to the fact that in order to solve many real world problems, a plethora of combined knowledge is needed to solve problems of such a nature.
>
> Katelyn: I had to synthesize several principles in order to complete the project, such as using a bending moment analysis and moment of inertia principles all in one segment.

> This allowed me to make connections between how various concepts work cohesively together in an engineering setting These are connections that I would not likely have made without the OEMP.

From these reflections, it is evident that the students have a difficult time developing a comprehensive understanding of an entire course's material due to the nature of typical homework assignments. These assignments often concentrate on mastering one unit at a time, rather than encouraging students to integrate information from multiple units. The OEMP combatted this by allowing students to engage with multiple concepts for one project. Concepts that were initially taught in independent units were woven together as the student-authors were forced to recall various units throughout the duration of the project. This helped to create a more holistic understanding of the statics course material and had a lasting impact on the students ability to recall course content. The real world applications of the project also had a significant impact on the students' comprehension of course material:

> Katelyn: The realistic aspect of the OEMP was beneficial towards my understanding of statics material. It was much easier to understand *why* we were learning the statics materials through the OEMP as compared to an abstract homework set. Since I was applying these principles in a practical manner, I had an easier time committing the information to my long-term memory because I was able to understand the context in which all of this content would apply.

The connection between theory and real-world application provided a contextual framework that made course content more meaningful, and therefore, more memorable. The first author was able to enhance her understanding of theoretical concepts through application to a real-world problem. By actively engaging with the material in a practical scenario, the students not only deepened their comprehension but also significantly improved their retention of the subject matter.

Engineering Identity/Becoming an Engineer

During the reflection period, both authors express how solving the OEMP gave them a sense of 'real' engineering, mimicking work that would be expected in industry. Typically in industry, much of the work engineers complete comes with little guidance, as the problems presented many times have never been solved before, leaving engineers to rely on their problem solving skills. The open-ended format given to students portrays a simulation of this type of experience, allowing students to develop these skills prior to working in industry:

> Jayden: I think learning these types of problem solving skills builds a really strong foundation for engineers once they enter into industry, which is where many of us will

> end up. This is because I feel… there is no context in the world of industry with which book work skills are directly necessary without the integration of problem solving skills.
>
> Katelyn: I enjoyed the realistic aspect of this problem because it was more representative of the work that a real-world engineer might perform. Most engineering coursework in the first two years of study are meant to teach necessary mathematical and analytical skills…[but] not representative of what a typical engineer's work would look like.

Both authors here discuss how they feel their experience solving the OEMP gave them ample time in performing tasks as an industry engineer would. Typically, engineering study many times only consists of abstract mathematical book work, giving little preparation for working in industry besides providing students relevant mathematics or physics knowledge. The OEMP shapes the student-authors' experiences by allowing them to develop problem solving skills necessary for a career in industry while integrating the knowledge gained from these abstract problems. The second author goes on to explain a direct relationship between the OEMP and an experience they had while working an internship at a local engineering firm:

> Jayden: Further, I had an internship with a local engineering company this past summer and obviously when it comes to industry, there are no textbooks or answers keys, so I had to use my knowledge of open-ended problems and problem solving to work on a lot of the projects they were asking me to complete… Just like for the OEMP project, I had to do initial research on the dimensions, materials, fit, purpose … I had to design it specific to that preliminary research, and finally I had to test it to make sure it worked.

This reflection, showing congruence between the work performed in both industry and throughout the OEMP, gives way to a first-hand experience and comparison of the skill sets required to complete both types of work. In completing the project this student-author was put on, they were reasonably prepared to complete the project as they were able to use the same foundation applied to their OEMP. Given the benefits of the OEMP in allowing for the development of problem solving skills, both student-authors feel it is important to offer OEMPs of this nature earlier in ones' engineering studies:

> Katelyn: Developing a problem-solving approach can allow an individual to identify their needs, strengths, and weaknesses. These…can also provide deeper insight about potential careers. This is crucial to develop in the first two years of engineering school because a student needs time to hone and develop a problem-solving approach. Moreover, early experience with problem-solving can allow students to alter their approach for different problems.

> Jayden: Students are exposed earlier to the fact that in the real world, the solution to a problem won't be directly taught to them right before that problem is given to them. It also exposes them to the fact that in order to solve many real world problems, a plethora of combined knowledge is needed to solve problems of such a nature. This type of knowledge and thought process is critical for students to get the hang of while there is still some guidance around to support them.

This suggests that both student-authors believe the earlier there is exposure to OEMPs, the more benefit students get out of the project. Both student-authors argue that since the open-ended format provides students the opportunity to develop their own problem solving skills, the earlier the introduction towards these types of projects is, the more time students will have while in school to continue to change and develop their problem solving approach. Further, both authors mentioned how the time with which this project is offered could be crucial in a future career choice as this project gives students exposure to what problems look like in industry and if they do not enjoy this type of work, the earlier they are exposed to it, the more time they have to deviate from engineering if they do so desire. Those who chose to complete this project and stick to engineering though may find this project enjoyable as the open-ended format helps them feel and think like an engineer:

> Jayden: I think that to me, learning this problem solving process was important because it solidified in me, my own ability to think like an engineer.

> Jayden: As well, it made me feel like I could be respected as an engineer or almost like I further had the right to call myself an engineer after having designed and worked through the OEMP.

> Katelyn: Therefore, I enjoyed getting to feel like I was doing work akin to what a real engineer might do. It was a great break from my typical homework assignments.

The student-authors both expressed how this project and the problem solving skills acquired while working on it have given them each fulfillment as an engineer. The second author expresses how this project made him feel as though he is an actual engineer, exclaiming the OEMP has allowed him to solidify his abilities and earn respect. Whereas the first author expresses how this project allowed her to feel like a real engineer and how for her, that was a very enjoyable experience. In providing these reflections, it is apparent that having worked on the OEMP, both student authors' engineering identities have been influenced as they both describe through this project what feeling like an engineer is to them.

Divergent Student Experiences

While negative feedback only accounts for a minority of responses, we choose to focus solely on this negative portion to explore the distinct perspective of students who did not positively

resonate with the statics OEMP, offering valuable contrast to the experiences detailed in the autoethnographic reflections. Several respondents expressed their reservations and challenges associated with the OEMP. One participant perceived the project as a distraction from the core class topics:

> Student1: I feel like it detracted from the actual class topics sometimes.

This is a strong contrast to the opinions expressed by the student-authors. Similarly, some students felt that the project had little effect on their comprehension of course material:

> Student2: The project didn't feel like it strengthen my understanding of the course. While I built real world skills I don't feel that it prepared me anymore for tests

> Student3: I didn't really think it helped me in my knowledge of statics and could've done without it.

> Student4: Benefited from it very little

Again, this is a distinct deviation from the ideas presented in the autoethnographic reflections, where both students felt their conceptual course understanding was deepened through the OEMP. Survey responses also suggest that several students felt that the time commitment was too taxing given the homework load of the statics class and other engineering courses:

> Student5: Overall I thought the OEMP was an interesting and helpful way to think and apply statics in a way more similar to that of a real life problem. I would say my one complaint is having weekly OEMP assignments combined with weekly homeworks and it would get difficult to balance these assignments with all my other coursework.

> Student6: The project sometimes distracted from my homework.

> Student7: [The professor should] make it not so much work? While dealing with other engineering courses and homework in this class as well

> Student8: [The professor] should seriously rethink time requirement compared to other course materials,

Here, it is evident that some students were unhappy with the rigor and demand of this project, an idea that is not represented by the student authors. While the survey data only offers a limited glimpse into an alternate perspective, these ideas are repeated through multiple years and are necessary to understand the multifaceted nature of the OEMP, eliciting both positive and critical

viewpoints among students. This recognition of diverse responses contributes to a comprehensive portrayal of the OEMP's influence on students' learning experiences in the realm of engineering education.

Discussion

The autoethnographic reflections, representing students' perceptions through our own student lens, provide unique insight into the direct student takeaways of working through an OEMP. Several conclusions emerged from the data that highlight how various aspects of the OEMP allow for a well-rounded engineering learning experience.

Deeper Learning

The OEMP project allowed both students to have more extensive interactions with course material, enabling a more profound and holistic understanding of statics concepts. The students spent additional time working with and connecting different concepts to each other. According to the principles of active learning, meaningful learning occurs when students select, organize, and integrate information [18]. This is precisely the type of control afforded to students during the OEMP as they independently select which concepts apply and integrate these ideas together in a single problem. Through this engagement, the OEMP promoted the student-authors to engage in deeper and more active learning, resulting in a better comprehension of course material during and after course completion.

Engineering Identity Development

Both students discuss the OEMP's impact on their ability to "feel like an engineer" through engagement with the real-world implications and ill-defined nature of the problem,which elicited a greater sense of fulfillment and enjoyment. This project evidently contributes to the development of an engineering identity, a crucial facet of supporting students' long-term commitment to the engineering field and fostering a greater sense of belonging among peers [19]. When students identify strongly as engineers, they are more likely to persist through challenges and setbacks, fostering resilience and determination in the face of rigorous coursework [20]. A strong engineering identity has also been linked to improved student retention in engineering programs [21]. This matters significantly for the field of engineering, as greater resiliency and retention contribute to a more diverse, skilled, and sustained workforce, ultimately benefiting the profession by ensuring a continuous influx of well-prepared and motivated engineers.

Interdisciplinary Implications

Both student-authors independently drew upon their experiences in English and social science courses while working on the OEMP, leveraging the research skills and familiarity with open-ended prompts acquired from these non-engineering disciplines. This underscores the

transferability of such skills across seemingly unrelated disciplines and reflects the real-world demand for multifaceted competencies.The students explicitly expressed the necessity of applying research skills from diverse courses, showcasing how interdisciplinary connections enriched their problem-solving approach in the unfamiliar OEMP context. It's noteworthy that while both student-authors had the opportunity to take AP English and social science classes in high school, not all students enter their undergraduate programs with a robust humanities background. This points to a potential gap in engineering education, where some students may not yet have had exposure to foundational research skills not typically developed through engineering courses. Incorporating interdisciplinary elements into engineering pedagogy is imperative as it ensures that all students, irrespective of their prior academic backgrounds, can cultivate essential research skills from other fields. This inclusive approach better equips students to tackle the complexity of modern workforce challenges, promoting a more comprehensive and adaptable skill set.

Freedom, Authority, and Agency

Freedom was the earliest and most prominently identified theme in the student-authors' reflections, defined by the students as the ability to make independent decisions about the problem without being constrained to a specific method or set of equations. This theme served as a catalyst for several other impactful outcomes, including the development of confidence, interdisciplinarity, and engineering identity during the OEMP. Where the student-authors use the terminology "freedom," others have used words such as "agency" and "authority" to describe the same ideas in existing literature [22], [23]. Engle and Conant define authority as "students having an active role, or agency, in defining, addressing, and resolving such problems" and they relate this principle to student engagement, claiming that students exhibit deeper engagement when forced to take a more active role in problem-solving [16, p. 404]. The OEMP propels students into this type of active learning by creating a sense of agency and authority among students, potentially leading to a significant improvement in learning and engagement as compared to typical engineering coursework.

Implications and Conclusion

From our analysis, we advocate for the incorporation of more problems that empower students to exercise agency in engineering coursework. The outcomes of our study underscore the significant benefits associated with such problem-solving approaches, providing students with opportunities to cultivate engineering skills and problem-solving frameworks beyond the scope of traditional coursework. The advantages identified in our research show that, through open-ended problems, students are allowed to experience freedom within an engineering framework, whether that be experimenting with different methods, or analyzing how numerical differences can impact final results. This process enables them to leverage their understanding of engineering principles, forming connections between course concepts and bridging the gap

between practical and conceptual aspects of engineering. Moreover, students learn to make informed and logical decisions when faced with unbounded problems. In an industry where rapid, critical decision-making on unprecedented issues is commonplace, a strong foundation in workplace problems like the OEMP are crucial for real-world readiness [24]. By engaging students in ill-defined problems, educators not only enhance their teaching methods but also provide students with a foundational experience that fosters independent learning and growth toward their future endeavors.

Our study also holds significant implications for the incorporation of autoethnography as a method in engineering education literature. By adopting autoethnographic approaches, we can directly examine the experiences of students, providing an authentic and nuanced perspective of their learning and growth. This stands in contrast to traditional student data collection methods, including surveys and interviews, that often rely on a researcher's perception of student learning, rather than interpretation by students themselves[1], [3], [25]. Autoethnographic methods offer a unique lens through which to explore the intricate facets of student experiences, allowing for a more genuine examination of their learning processes, challenges, and growth within engineering education. This shift towards a student-centric perspective enhances the richness and depth of our understanding, paving the way for more comprehensive insights into the effectiveness of educational practices and methodologies from the learners' standpoint. Embracing autoethnographic method empowers educators and researchers to bridge the gap between pedagogical intentions and students' actual learning experiences, fostering a more informed and student-focused approach in engineering education literature.

Acknowledgements
This material is based upon work supported by the National Science Foundation under Grant No. 2313240. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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