

## Exploring Student Responses to Utility-value Interventions in Engineering Statics

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## **Exploring Student Responses to Utility Value Interventions in Engineering Statics**

### **Abstract**

In this research paper, we explore student responses to Utility Value Interventions in statics courses. Introductory engineering mechanics courses (e.g., statics, dynamics) are critical points within a curriculum, and student performance in these courses can have a strong influence on future success. And while these courses are often thought of as “weed out” courses, the ubiquity of these courses for engineers is what makes them an important place for students to develop the motivation to persist through their engineering education. One particularly promising tool for this development has been Utility Value Interventions (UVIs) in which students are given opportunities to reflect on how their coursework aligns with their lives through short writing prompts. But while UVIs have helped improve student interest and success in subjects such as biology and psychology, their use in engineering remains limited. Further, while research has demonstrated the effectiveness of UVIs, the specific content of student responses to them remains relatively underexplored. To address these gaps, we to explore the content of student responses to UVIs and to examine how students make connections between their values and their learning and success in statics. In the fall 2020 term, we distributed a UVI in which we asked students to describe their personal values and articulate how they will be useful for success in the course. We used thematic analysis in combination with in-vivo and descriptive coding to characterize student responses and examine how they make connections between their personal values and the ways those values might contribute to their success in the classroom. Three dominant themes emerged from student responses: 1) Self-improvement; 2) Empathy/Kindness and 3) Helping. These themes provide a better understanding of the kinds of values that are important to students and offer insight into their interest and motivation as it relates to learning in engineering mechanics. Given the abstract, decontextualized mode in which engineering sciences are typically taught, instructors can work to identify and develop these personal connections and enhance student motivation and expectancy for success in what are foundational areas of an engineering curriculum. In particular, our results point to the importance of connecting engineering learning to students’ values related to improving society and forming positive interpersonal relationships. To cultivate student interest, including discussions or assignments that integrate these values can benefit students who might be struggling to find personal relevance to their engineering curriculum.

### **Introduction and Background**

Engineering Statics courses represent a significant point within a curriculum for many engineering students. For one, they are often students’ first “real engineering” class where they apply the concepts learned in math and physics to engineering scenarios and where they conduct analysis of various structural elements. But the problems presented in statics often depict scenarios that are esoteric to students and present contexts with which they might have relatively little direct experience or familiarity (e.g., simply supported beams with arbitrary loads, moments of inertia, hinges in series, etc.). As a result, students can struggle to make meaningful connections between the content they are required to learn in statics and their own experiences in the “real world.” Indeed, in the authors’ experience, many students have noted that understanding statics is important simply because they will need it for dynamics or other classes for which it is a prerequisite. But this kind of connection is both tenuous and problematic; when students cannot see how what they are learning applies to or is useful for their goals (beyond needing to know the material for subsequent courses) they are less likely to be motivated by that content and thus more likely to fail or withdraw from the course or major altogether (Klingbeil, Mercer, Rattan, Raymer,

& Reynolds, 2004; Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larпкиattaworn, 2007; Steenkamp, Nel, & Carroll, 2017). It is therefore vital that students are able to recognize and make connections to statics in ways that are meaningful to their lives beyond simply needing to know it for its own sake.

To address this issue, we implemented Utility Value Interventions (UVIs) in statics to help students more readily see and thus articulate the ways in which their learning can be related to their own personal values and goals. While UVIs have been successful in improving student success and motivation measures in different STEM contexts, the content of student responses to UVIs remains largely unexplored. To address this gap, we explore the content of UVIs to better understand the ways in which students connect statics to their own lives. By explicating these connections, we hope to generate interest and motivation for all students, but especially those for whom this content might not immediately resonate. The purpose of this paper is to offer examples of the ways students make connections between their personal values and their learning in statics in ways that can ultimately inform pedagogical content and choices in engineering mechanics courses. We argue that by helping students explicate the usefulness of statics for their goals beyond subsequent coursework, we can increase motivation and interest in the content and, ultimately, performance and persistence in engineering.

The following sections provide a brief review of literature related to motivation in engineering education, the use of UVIs in higher education settings, and existing gaps in UVI research. We then describe the methods implemented to collect and analyze student responses to the UVI we developed. Next, using thematic analysis and first-cycle coding methods (Saldaña, 2015), we present our findings in terms of three dominant themes in student responses that concern 1) Self-improvement; 2) Empathy and Kindness; and 3) Helping. Finally, we discuss our future work and potential implications for enhancing motivation and interest in engineering statics courses.

### **Motivation, Utility Value, and Success in Engineering Education**

Motivation, as defined here, is informed by Eccles' Expectancy-Value Theory (EVT) (Wigfield & Eccles, 2000). EVT posits that an individual is motivated to engage in a task when they (a) expect to succeed on that task (i.e., expectancy for success) and (b) perceive that task as useful to their personal goals (i.e., task value). This framework has been used in a range of engineering education contexts to examine the ways different students derive motivation from their experiences in and beyond the curriculum (Matusovich, Streveler, & Miller, 2010) as well as different kinds of tasks that might serve as sources of motivation (Jones, Epler, Mokri, Bryant, & Paretti, 2013; Lee, Kajfez, & Matusovich, 2013; Holly M Matusovich, Paretti, Jones, & Brown, 2012). Motivation is critical to success in an engineering curriculum and existing research has shown the ways in which motivation is related to relevant factors such as performance (Koh et al., 2010); retention and persistence (French, Immekus, & Oakes, 2005); career choice (Kolmos, Mejlgard, Haase, & Holgaard, 2013); and a range of positive student behaviors (Jones, Paretti, Hein, & Knott, 2010). We use EVT here because of its grounding in STEM fields in developing a deeper understanding of student choices and motivation as well as the focus on the personal importance of a given task.

In this work, we focus on two particular aspects of EVT: Utility Value and Expectancy for Success. Utility value refers to how a particular task relates or contributes to an individual's future plans or goals, while expectancy for success refers to an individual's beliefs about how well they will do on upcoming tasks in the future (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). We focus

on utility value because prior research has shown that when students can articulate the ways in which course content is personally useful or important to them, they are more likely to engage with the material and perform at higher levels (Canning et al., 2018; Kosovich, Hulleman, Phelps, & Lee, 2019)—this is especially true for underrepresented and minoritized groups in STEM (Harackiewicz, Canning, Tibbetts, Priniski, & Hyde, 2016).

We also concentrate on expectancy for success because literature states that when students believe they can succeed they are also more likely to stay motivated (Eccles & Wigfield, 2002). This effect has been observed specifically within engineering (e.g., (Jones, Epler, Parastou, Bryant, & Paretto, 2013; Jones et al., 2010; Matusovich, Streveler, Loshbaugh, Miller, & Olds, 2008; Matusovich, 2008)), and so it seems important to examine the ways UVIs might be able to promote student motivation here. By helping students explicate the personal usefulness of a given topic or course and identifying values that will contribute to their success, they are more likely to develop and sustain interest in that topic (Hecht, Grande, & Harackiewicz, 2020; Hulleman, Kosovich, Barron, & Daniel, 2017), which is positively related to persistence and performance (Lent, Brown, & Hackett, 1994). UVIs thus represent a promising avenue to both enhance student motivation and allow researchers to explore the sources of that motivation.

### **Utility Value Interventions**

UVIs are designed to help students make connections between the content they learn in a given course and its relation to their own lives and experiences. These interventions often take the form of short writing assignments that prompt students to examine a recently covered course topic and describe the ways that topic relates to various aspects of their life (we offer a contextualized example below). UVIs are supported by expectancy-value theory (EVT) and focus on the utility value aspect of the EVT model by encouraging students to make personal connections in ways that can enhance interest and performance (Hulleman, Godes, Hendricks, & Harackiewicz, 2010).

While UVIs have been effective in STEM fields broadly, their use in engineering in particular remains limited. However, some emerging work has shown potential for the success of UVIs in engineering design settings (Turoski & Schell, 2020). For example, Turoski & Schell (2020) explored the effects of UVIs on student interest and motivation levels in an engineering design class with the use of pre- and post-intervention surveys. Although findings from this research are still emerging, the authors note the potential of such work to contribute to a better understanding of engineering student motivation as well as help students think about the ways course content might extend beyond the classroom. Notably, the authors mention plans to conduct a qualitative analysis related to the specific content of the UVIs they implemented, suggesting that in addition to these interventions being valuable on their own, better understanding the specific contents of UVI responses can yield further insight into student motivation and interest. Studying the content of student UVI responses can offer a deeper understanding of what personally motivates students to learn in engineering science courses. Given the limited nature of this work and the potential for UVIs to contribute to student motivation and success, there is a need for researchers to probe the effects of such interventions in a range of engineering education contexts.

While UVIs have been shown to be powerful mechanisms to increase student interest, motivation, and performance in a range of courses, the specific content of student responses remains largely unexplored. Moreover, while existing research has shown that UVIs have positive educational impacts in a range of higher education contexts, their use in engineering in particular remains

limited. By exploring the specific content of what students write about in their UVIs, responses can offer insight into the specific aspects of their values that can inform educational and curricular decisions about how to integrate these topics with technical content. In doing so, they can strengthen students' personal connections to the content, potentially helping them persist in engineering. To that end, we aim to address these gaps in literature by exploring the themes present in student responses to UVIs in an engineering statics context.

### **Methods**

The purpose of the present work is to explore the content of student responses to a UVI related to personal values in an engineering statics course. But the research presented here is part of a larger project aimed at closing racial and gender equity gaps in introductory mechanics courses (i.e., physics, statics, and dynamics). As part of the project, we are working to develop motivational and interest-generating content to help students see more value in what are foundational courses for engineers and to do so in ways that appeal to students who might be most at risk of withdrawing from this course (or engineering altogether).

### **Data Collection**

Data were collected during the winter 2020 quarter at a large, public, polytechnic institution on the west coast of the US. A total of 101 (out of a possible 104) students across 3 sections of statics opted in to allow for their responses to be used as data. We developed five short writing prompts that were assigned as student homework and in this paper we focus on one that asked students to articulate their values and describe how those values might help them succeed in the class. Past UVI research has focused on utility value primarily, but this specific was expanded to also address students' expectancy for success. For the present work, we used the following prompt:

*Research has shown that evaluating personal values and affirming them can trigger positive reinforcing outcomes which lead to enhanced academic performance (Tibbetts et al., 2016). Using the list of core values posted to Canvas [learning management software], identify two or three values that are important to you. Describe what you do to incorporate these values into your everyday life. Lastly, evaluate how these values may be helpful to you during the course of this class. Your response should be at least 250 words.*

Students were provided a list of different "core values" that they could choose to write about, such as *acceptance, courage, organization, creativity, stability, status*, etc. and these values were used to focus their discussion. Data were collected via the Concept Warehouse (Koretsky, 2020; Koretsky et al., 2014), an online platform designed to help students gain conceptual understanding through a range of formative and summative assessments. For this research, we utilized a tool that allowed student responses to remain anonymous throughout the quarter but that the instructor could still offer feedback on (e.g., Koretsky, 2020). As a result, the instructor was able to see who completed the assignment, but could not attach any individual responses to specific students until grades had been finalized for the Fall 2020 academic term. We used this tool because it would allow for streamlined data collection and also give students the opportunity to opt out of having their responses used as data. Students were assigned a random numeric identifier so that responses could be linked to specific students throughout the course without being identifiable by the instructor. We use these identifiers to label the student quotes in the Results section.

Although students were prompted to enter demographic information, filling out the demographic survey was optional and only 44 out of a possible 101 students entered their demographics. As a result, we have omitted student demographic information from the present analysis. However, it is important to note that the use of UVIs shows promise for increasing motivation and engagement for minoritized and marginalized groups in engineering (Harackiewicz et al., 2016), and so future research should ensure the collection of demographic data to better understand how different populations of students interact with these assignments.

### Data Analysis

The analysis was primarily conducted by two undergraduate research students. We followed recommendations for thematic analysis by Braun & Clarke (2006), who lay out six major phases that move from familiarizing with the data to completing the final report. An important note about thematic analysis and qualitative coding in general is that while the process is presented as a linear, stepwise sequence, the analysis is iterative and recursive, with movement in between and across phases as themes emerge from the data.

During the first phase, we individually reviewed the entire corpus of UVI responses (N = 101) and developed common topics or themes that we believed to be salient. Here, we identified values related to ideas such as “helping” or “success” and these values informed the generation of initial codes during phase 2. During the second phase, we conducted open coding in line with recommendations for first cycle methods by Saldaña (2015) to identify key words or phrases that might serve as codes in subsequent rounds of analysis. The open coding phase was conducted together for the first few excerpts and after consensus was reached, the remaining excerpts were open coded were split between the two researchers. The excerpt in Table 1 offers an example of the ways we identified potential codes within student responses during phase 2.

Table 1: Example of open coding process for student values

Student UVI Response	Initial Open Code
<p><sup>[1]</sup> The core value that means the most to me is family. Despite how annoying they may be, I have a very good relationship with my family. During this pandemic, I have been forced to be closer than ever to my family because I am not supposed to meet up with friends. This has made me realize more than ever how thankful I am to have such a family. We may constantly tease each other, but, at the end of the day, we always come together and work seamlessly together. <sup>[2]</sup> I incorporate this value into my everyday life by simply communicating with them. Even when I am in SLO, we weekly facetime so that we can catch up with each other. <sup>[3]</sup> The second core value that resonates most with me is curiosity. I am, and always have been, a very curious person. I enjoy tinkering with things and trying to understand how they work. This trait was a driving force for me to major in mechanical engineering because designing products and understanding how they work go hand in hand. <sup>[4]</sup> This trait will be very useful for me in this course because it will give me extra motivation to do be interested in the material. I understand that the material covered in this course is foundational to future engineering courses. Since I am curious about how things operate in the real world, I will be more interested in this course. <sup>[5]</sup> I also understand that this course will be challenging. When I get stressed out, I can always take a step back and connect with my family to calm my stress. Talking about stressful things does wonders.</p>	<p>[1] Family</p> <p>[2] Communication and Relationships</p> <p>[3] Curiosity and Learning</p> <p>[4] Success in Course and Engineering</p> <p>[5] Overcoming Challenges/Stress</p>

Knowing that my family is always available to talk to gives me an extra sense of security which helps me push myself further.	
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During phase 3, these codes were grouped together according to similarities and differences that helped clarify the ways students expressed their values. The groupings of these codes were developed through discussion meetings where we presented and compared our individual findings from phase 2. These meetings allowed us to synthesize our observations of the participants' values and how they related them to their potential success in statics. We focused on values related to improving oneself, helping others, and maintaining productive relationships and interactions because these were categories that emerged as salient in student responses. During phase 4, we reviewed our potential themes and codes and recoded the dataset using updated operational definitions. This process helped us to strengthen the meaning of each of our codes in relation to each other through deliberating about the boundaries and scope of each. Here, we reviewed each coded segment within and across categories to define the conceptual boundaries of the codes that emerged from analysis. This process entailed sorting all coded segments within a given code and examining both within and across codes for consistency and clarity. During phase 5, we finalized our codebook and established the relationships between codes and themes and the hierarchy that separate and describe each. Finally, phase 6 entails producing a report. It is our hope that the reader finds the reporting of the themes in the following section coherent and compelling in describing the role of student values and their connections to engineering statics content. All data were coded by the first two authors. To establish credibility and trustworthiness, the codebook was provided to the final author and a subset of data were coded independently, with discrepancies being argued to consensus to reach a final agreement on the definitions and conceptual boundaries of the emergent codes.

### Results

Our results focus on emergent findings resulting from the thematic analysis approaches described above. Overall, three major themes emerged from student responses to our UVI, which embody the types of values that students express and recognize to be useful for their success in statics. *Self-Improvement* focuses on values that describe the importance of working on oneself, making efforts to overcome challenges, and achieving balance in one's life. In contrast, *Empathy/Kindness* concerns affective values and the importance of understanding others and developing a sense of compassion—both at interpersonal and societal levels. Finally, *Helping* describes values related to working with and improving the lives of others—again at the interpersonal and societal levels. Table 2 offers an overview of the three dominant themes along with their operational definitions and brief examples. Each theme is comprised of different codes and is further elaborated in the following sections.

Table 2: Overview of emergent themes, definitions, and examples

Themes	Operational Definition	Examples
<b>Self-Improvement</b>	Personal development of an individual in the pursuit of enhancing their quality of life.	- Leveraging values to overcome challenges and adversity, to grow as a person, and to find balance in one's life

<b>Empathy/Kindness</b>	Conscious effort to understand and alleviate the struggles of others by integrating affective values.	<ul style="list-style-type: none"> <li>- Supporting and caring for a specific person or group</li> <li>- Having a compassionate mindset to improve the state of society as a whole</li> </ul>
<b>Helping</b>	Contribution to the betterment of personal relationships and society as a whole.	<ul style="list-style-type: none"> <li>- Striving for positive interpersonal character traits as a peer or teammate.</li> <li>- Commitment towards positive societal contributions</li> </ul>

## Self-Improvement

The first theme emphasizes students' individual development in the pursuit of enhancing their own quality of life. Here, students describe their values of growing in important personal areas, overcoming challenges, and finding stability and balance in their lives, then recognize how these values will contribute towards their statics experience.

### *Personal Growth*

*Personal Growth* describes student efforts to enhance their lives and develop in areas that are personally important to them (e.g., becoming a better engineer, family member, piano player, etc.). In this context, we defined this code as student discussions of the value of gaining insight about themselves and their interactions in the world around them. The following quote demonstrates how some students value curiosity to continuously learn and they link that curiosity to their ability to grow as a problem solver which will aid them as they complete class assignments and exams.

*I really value curiosity because learning new things is something that excites me and gives me a thrill. Curiosity has personally led me to discovering new things about myself and the world around me. I incorporate curiosity into my life by being inquisitive, seeking to understand how things work, and exploring the unknown. I believe that staying curious will help me in this course because it will make me a better problem solver. [Student ID 8241]*

By integrating this sense of curiosity into their lives, this student enhances their ability to learn more about both themselves and the world around them. This student expresses that this value will be useful in statics, as their curiosity will contribute towards their problem-solving abilities—a critical skill in engineering science courses.

### *School Life Balance*

Additionally, students communicated the value they assigned to having stability and order in their lives as engineers, family members, athletes, hobbyists, etc. We defined *School-Life Balance* as responses related to drawing boundaries between academic and personal life and working to find harmony between them. Here, it was important for students to make space for things they value so that they could achieve personal fulfillment and satisfaction in their personal and academic lives. Students express that a healthy stability among multiple areas in their lives, they are able to enter the academic space with a clear mind, improving their quality of learning. In the excerpt below, a student describes the value of balance and the importance of managing their time spent in their extracurricular activities in relation to their schoolwork.

*Another value that I find hard to implement but that is incredibly important to me is balance. In an ideal world, I would have perfect balance between school, staying healthy, recreation, practicing mindfulness, participating in activism,*



*and socializing. It is easy to lose touch with central aspects of your values and interests during the constantly busy lifestyle of college. By focusing on balance, I remind myself that school is not the only essential part of my life. I make sure that I exercise most days and commit time to hobbies and relationships with friends and family...This quarter, I will strive to find balance in this class and with my whole course-load by giving myself breaks to re-energize and by equalizing out stress with joy [Student ID 8333]*

This student articulated the importance of maintaining hobbies and interests beyond academic spaces. Having balance between multiple aspects of their life allows them to approach their learning with more focus and less stress.

#### *“Stick-to-itiveness”*

Students expressed their desire to leverage values such as hard work, optimism, and mental fortitude to persevere in the demanding engineering curriculum. We defined “*stick-to-itiveness*” as the values related to determination and persistence in the face of adversity as well as the methods students use to overcome significant academic and personal challenges. The following excerpt highlights how some students prioritize understanding a subject and concentrating until they fully grasp the correct solution.

*The most important core value to me is focus. When I become interested or excited by a project or problem in my life, I prefer to divert all my attention to mastering the project or solving the problem before returning to anything else. I demonstrate this in many aspects in my life. With school, once I start an assignment or project I will keep working until it's finished, and I often will attempt to focus for long periods of time to finish all my work early. I believe this trait will be key for this class, because when presented with a challenge in the form of a problem set or upcoming midterm I will focus until I feel confident with my work. [Student ID 8436]*

Here, the student leverages their value of “focus” to channel their energy into achieving proficiency with a given subject. This ability to persevere and *stick to it* was an important part of developing confidence with course material and students saw this ability as critical to their success in the class. Discussions of personal growth were important for helping students make connections between values and course content in ways that resonated with their individual experiences. They applied those values to the course to enhance their success and overcome significant obstacles.

### **Empathy/Kindness**

The second key theme focuses on instances where students expressed affective values towards the wellbeing of those around them and recognize their utility in statics. Here students articulated values related to *Empathy and Kindness* through both interpersonal interactions as well as toward society more broadly. Both of these orientations are highlighted in the following sections.

#### *Interpersonal Empathy/Kindness*

At the interpersonal level, Empathy and Kindness describe how students utilize their personal values to understand and support other individuals. By acknowledging their own personal struggles and those of students around them, students are able to empathize and aid one another. In the excerpt below, the student reflects upon their value of being patient in order to acknowledge the position of others and remain understanding in light of frustrations.

*I try to be as patient as possible in my daily life. One way I incorporate patience into my everyday life is when I am on edge or frustrated with someone about something, I try to take a deep breath and see the situation from their perspective and recognize that losing my cool will not make the situation better but actually worse. Empathy will be important in this class because if I am able to see problems and interactions from other people's perspectives it will ease most tensions and allow us to work more effectively as a group. [...] Patience will be important in this class because if I am able to remain calm and levelheaded on homework, quizzes, midterms, groupwork, etc. I will achieve at a higher rate than I would if I easily lost my cool and got frustrated. [Student ID 6349]*

Here, the student connects their ability to exercise empathy and patience to two vital aspects of success in engineering curricula: effectiveness in team work and performance on tests.

### *Societal Empathy/Kindness*

In addition to interpersonal interactions, Empathy/Kindness was described on a more macro-level. For students in this research, Empathy and Kindness could also be expressed at a societal level and was discussed in terms of how they treat others in a broader sense. Here, students do not specify certain groups or individuals to show compassion towards, rather the focus is placed on an empathetic worldview and the societal benefits of others adopting this worldview. Students also recognize the role of their social values in engineering, which serve to further motivate them in their learning experiences. In the following excerpt, a student expresses how values surrounding inclusion can not only improve the service engineers provide but also the quality of society as a whole.

*Forming personal relationships with people who are different than you will get you invested in the wellbeing of groups that you might not necessarily be a part of. Being able to see disabled people, women, LGBTQ+ people, or people of color sharing the same spaces and working towards the same goals as us will make us start to think about helping meet someone's needs that aren't our own or that we may have never in our lives even thought of. Exposure to different people with different worldviews will expand our perspectives and make us better engineers and people. [Student ID 4766]*

For this student, empathy is described as the ability to take on the perspectives of broader populations of individuals; in this case, those with marginalized identities. The student connects this value of inclusion to engineering through the importance of understanding different worldviews and expanding their perspectives to become better engineers. Research in human-centered design emphasizes the importance of empathy (Zoltowski, Oakes, & Cardella, 2012) and illustrates the ways in which the ability to consider the complexity of issues experienced by groups different from oneself is critical to effective design and decision making.

### **Helping**

Where Empathy and Kindness concerns values related to understanding others' perspectives and accounting for them in interactions, *Helping* emphasizes how students work to improve their relationships with others. Our final theme, *Helping*, is defined by as the values that contribute to both local relationships as well as broader society. Similar to Empathy and Kindness, this theme is expressed at both the interpersonal and societal level with different emphases.

### *Interpersonal Helping*

Interpersonal Helping was expressed through value expressions related to enhancing interpersonal interactions and relationships. For instance, interpersonal helping is expressed through values of loyalty, accountability, communication, etc. to promote healthy working relationships with others which will serve to be beneficial in one's statics learning experience. In the excerpt below, a student reflects upon their value of dependability, its effect on relationships, and its priority as a key for success both in and out of the classroom.

*I think dependability is one of the most important traits a person can have. A person's word is sacred and once credibility is lost, it is hard to ever rely on that person again. Throughout relationships, friendships, partnerships, anything when working with another person, dependability is one of the most important things when working together. [...] I think [this value] can help not only in the classroom setting but in life, business, and relationships. By supporting and uplifting those around you, you create an environment for not only yourself, but those around you to thrive in. [Student ID 6135]*

For this student, being dependable was seen as a way to uplift others to promote their personal success as well as the success of those around them. This dependability was perceived to be helpful in multiple areas of their life in addition to their learning in class.

### *Societal Helping*

This code focuses on instances where students express how they desire to use their skills and knowledge to contribute to the positive changes in society. For example, students who are passionate about problems such as environmental impacts, social injustices, etc. identify how their learning will aid them in their dedication towards those problems. The excerpt below expresses values related to service, specifically towards "people and the planet" and describes how the student works to align their technical skills with these values.

*I [value] 'service' primarily because I want to use what I learn to help people and the planet. I believe that acts of service are important on a personal and professional level and that anyone that has the privilege of receiving a technical education has an obligation to use their skills to make a positive change in the world around them. [...] [I] hope that one day I might work on satellites that help detect, monitor, and combat fires, thereby saving lives and preserving the forest. [Student ID 8481]*

The student views their education as something that positions them such that giving back to society is an obligation they have. Societal helping helps illuminate the ways in which students see earning and engineering degree as a way to give back to society. (Though it is beyond the scope of the present study, we do note the use of the phrase "technical education" to seemingly describe the process of earning an engineering degree, and recognize the dualistic ways of thinking that might be present.)

### **Results Summary**

Student responses to the Value Affirmation UVI illustrate a wide range of values and connections to learning in engineering statics. Students leverage values related to self-improvement to support their own learning and development and to persevere in the face of significant challenges. At the same time, students also expressed values related to helping those close to them and in broader

society by cultivating empathy and kindness. While it is not necessarily surprising that engineering students hold these values, it is noteworthy that students are able to articulate how these values might apply or be important for success in an engineering science course. Given the ways in which students express values related to positive personal, interpersonal, and societal change, it seems important that engineering educators give students further opportunities to integrate their values into the work they do and make positive connections between those values and engineering science courses.

### **Discussion and Implications**

As we have undertaken this project, a running joke within our research group has been the phrase “statics is important because statics is important.” That is to say, topics within engineering science courses are often perceived as important to students mostly because the professor tells them that the content is important or that it will be necessary for students to succeed in courses that build on the current one. In the case of statics, topics are deemed important in large part because an understanding of statics concepts is vital to success in dynamics or mechanics of materials—courses where they apply statics to more complex scenarios. But beyond simply needing material for an upcoming class, helping students see relevance and relatedness to their personal lives and values can serve to increase motivation and, in turn, enhance learning and engagement with course content. The following section offers a discussion of our findings, the contribution to existing literature, and implications for researchers and educators.

### **Utility Value Interventions and Student Motivation**

Our findings present a qualitative approach to UVI analysis and explore the specific aspects that students find relevant and valuable as it pertains to their engineering science learning. We used UVIs to help students make connections between their personal values and ways those values may be useful in engineering science to enhance motivation. While Hulleman et al. (2017), Turoski (2020), Hecht et al. (2020) and others have demonstrated the positive effects UVIs have on levels of student motivation and academic success, limited work has explored the specific content of those connections. Our research thus unpacks the “black box” of how UVIs function and how students respond to them. Unpacking in this way can help educators better understand aspects of student motivation and explicate how they align their personal lives to their learning experiences.

In particular, we demonstrate how engineering students’ sources of motivation move beyond technical competency and emphasize a range of personal and interpersonal values. Students recognize ways that their values will positively affect their learning experiences and how their learning can be used in conjunction with their values to help achieve their personal goals. For example, the theme of *Helping* shows that students value their ability to both support others in their interpersonal relationships in the classroom and make a difference in society overall. Prior research has illustrated the importance of societal impact for engineering students’ decisions to enter the major and the content of student UVI responses tend to corroborate and provide support for those findings (Bielefeldt & Canney, 2019; Watson et al., 2015). Researchers have also demonstrated the critical links between perceived value of an activity and success and persistence on that activity (e.g., (Andersen & Ward, 2014; Thomas Jr, Wolters, Horn, & Kennedy, 2014)).

### **Using UVIs in Engineering Education Research**

We argue that by providing these opportunities to reflect on values afforded by UVIs, engineering educators can tap into student motivation in meaningful ways. One way to do so is to simply use UVIs across a broader range of engineering science courses. Doing so can help students see, over

time, how their own values and motivations are related to specific aspects of their disciplinary knowledge. Exploring these connections can help students make more informed career choices in terms of where they might want to focus or what kind of engineering discipline they want to enter after graduation. Another way to leverage student values is to integrate the findings from current and future research into engineering science course content. For example, our results point to the importance of helping and societal change as important for engineering students in our sample. Instructors can leverage these findings to design course content that explicates the ways in which engineering science content might enhance students' ability to engage in helping at both interpersonal and societal levels. More work is needed in this area, but educators can work to incorporate discussions of values in ways that help students see the broader impact of their engineering knowledge on the world.

### **Conclusion**

The purpose of this research was to examine the content of student responses to UVIs in an engineering statics course and to leverage that content to better understand how students make connections between their own lives and values and engineering science content. We leveraged existing tools from research in other STEM fields (e.g., (Canning et al., 2018; Hulleman et al., 2010)) to develop a UVI that asked students to describe their own personal values and how they perceive those values as related to their learning in statics. Where prior work has examined the impact of UVIs, less work has explored the specific content of student responses. Using thematic analysis approaches, we developed three emergent themes that highlight student values in terms of personal growth and a desire to cultivate positive relationships with individuals close to them (e.g., teammates) as well as with society more broadly. In connecting their values to course content and learning, engineering students can be more mindful of the ways in which their learning is personally important to them and can therefore be more likely to persist in the face of adversity and curricular challenges. By offering students space to reflect on and connect their values with engineering science content, UVIs have the potential to enhance student motivation and success.

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