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Mediating Expectations: Understanding the Influence of Grades on Professional Identity Formation in Undergraduate Engineering Students

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Introduction

Course grades play a significant role in undergraduate students' professional development as engineers. First, they are the primary indicator of workforce readiness (i.e., students must achieve a certain grade point average to pass their courses and be awarded an engineering degree). The rationale is the higher the grade earned in a course, the more disciplinary knowledge and concepts the student is assumed to have mastered. But while faculty use grades to provide feedback to students regarding knowledge accumulation within a curriculum, they also hold implications for the ways students experience school. For example, grades influence the number of scholarships and types of financial assistance offered to students, with higher grades yielding more financial support. They are used to determine eligibility for entrance into certain academic and sports programs, and in some instances, can qualify or disqualify students from certain co-op, internship, and other career development opportunities.

However, approaches, philosophies, and policies toward grading can vary drastically across individual faculty based on the type of assessment practices they choose to adopt in their courses. In addition to traditional formative and summative assessments, prior literature has identified other forms of assessment including standards-based, competency-based, mastery-based, and adaptive [1]. More recently, the practice of ungrading has become more prominent in the humanities and social sciences and is slowly being adopted by engineering education. In courses that utilize ungrading, students are required to develop a portfolio of writing intensive or other types of projects in lieu of traditional assignments [2]. Students are expected to submit their work for review, obtain feedback from the instructor, and implement that feedback over the course of several submission iterations throughout the semester. At the end of the course, the student meets with the instructor to discuss the final grade to be awarded. Proponents of ungrading argue that this practice shifts the student learning experiences from a focus on earning a particular grade to emphasizing the process of learning itself. Recent work by Carberry *et al.* [3] has attempted "to clarify what has become a confusing landscape of grading systems" in engineering education by situating these approaches on a continuum from learning outcomes-based grading to norm-based grading. While frameworks such as these have been developed to help faculty identify and implement assessment and grading techniques within their own courses, the fact of the matter is many engineering faculty have not had formalized teacher and curriculum development training and tend to adopt grading practices and policies they were exposed to as students [4]. As a result, grading has become an important yet unpredictable measure of performance that can drastically shape the ways students navigate their undergraduate experiences to become engineers.

To date, little work has explored the interplay between course grades and professional identity formation in undergraduate engineering programs. However, these links have been highlighted in literature that tends to describe engineering educational culture as inherently valuing performance and productivity encompassed by an aura of exceptionalism. For example, Stevens

et al. [5] identified engineering educational culture as a meritocracy of difficulty in which one's ability to persevere through difficult content is a marker of an engineering student's worth. Similarly, Dryburgh [6] described engineering as a work hard, play hard culture in which students are commended for lengthy study sessions and sleepless nights. Work by Rohde *et al.* [7] found when asked who can become an engineer and what is needed to be successful in engineering, undergraduate student participants' responses indicated an openness that anyone can become an engineer as long as they conform to certain cultural expectations such as those highlighted by Stevens *et al.* [5] and Dryburgh [6].

In this study, we draw from situated learning perspectives [8] to conceptualize engineering education as a site of engineering identity formation in which students learn not only engineering content, but also the valued norms, behaviors, and language associated with the engineering profession [9]. Grading serves as a feedback mechanism in which individuals who belong to engineering or identify as engineers (i.e., engineering faculty) communicate to students their level of belonging or development as an engineer in the form of course grades. To further explore this relationship, we ask the following research questions: (1) How do undergraduate students' interpretations of course performance influence the formation of their professional identities? and (2) How do undergraduate students' interpretations of course performance change based on program experience (i.e., academic level)?

Researcher Positionalities

Jackson Smith, Junior Mechanical Engineer, Utah State University. When I was a freshman in college, I suffered from extreme anxiety regarding coursework, grades, and content comprehension. After scoring what I believed was too low in one of my engineering classes, I began to experience health issues stemming from my stress. A mentor of mine recommended therapy and spoke to me about the benefits of properly managing mental health. I began prioritizing my mental health by attending therapy and working to understand my stress. During therapy, I began to understand how I process grades and how I can better deal with the stress and rigor of my engineering program. My journey to understand how I interact with my own professional identity inspired me to participate in this study and learn how grades impact professional identity formation in others.

Ilham Kabir, Junior Chemical Engineer, The University of Maryland, College Park. During the first semester of my engineering program, I found myself questioning my capability to become an engineer due to my coursework and assessment performance which I considered unacceptable. Although I had always done well in STEM-related courses, I couldn't quite find the balance between excelling and retaining information and ended up snowballing my doubts and suspicions throughout the semester. During the break between semesters, I took a step back and spent time to understand where my focus should be with grades and how I should improve myself to not allow hiccups to falter my drive towards becoming an engineer. With my experience and current understanding of how grades can influence identity formation, participating in this study provided me with an opportunity to gather more insight into how grades influence others' perceptions of their identities.

Cassandra McCall, Assistant Professor, Utah State University. As someone who performed well in high school, my transition into my engineering program was very difficult. I was constantly overwhelmed with the difficulty and amount of homework assignments. I felt like I was always running from one deadline to another, one exam to another, and one course to another. Due to the high-stakes nature of the exams in my courses, I developed testing anxiety and struggled to retain the valuable concepts I was trying to learn. During my third year, I began to doubt by ability to become a civil engineer, I often regretted my decision to pursue a STEM career, and I almost left STEM entirely. For me, this research is a way to help students recognize they are not alone in these challenges and to spread awareness of these challenges among engineering faculty.

Theoretical Framework

To examine the ways students' interpretations of course grades influenced professional formation among undergraduate mechanical engineering students, we grounded our study in social identity theory (SIT), which is also referred to as group identity. SIT posits that membership in a group is established through comparisons of values and behaviors members make between themselves and other groups [10-12]. Through these comparisons, members partially define who they are and communicate those definitions based on the values, traditions, and practices to which a group ascribes [10]. At the same time, sub-theories of SIT, self-categorization theory (SCT) and intergroup relations, emphasize the double-sided perspective of identity in which individuals not only position themselves but must also be positioned by others as part of that group [5]. Due to the emphasis on performing at high levels in order to become an engineer, we applied this theoretical lens to determine how grades serve as an indicator of identity both for individual students and for others.

Methods

To address our research questions, we conducted a qualitative study consisting of two phases of data collection. In Phase 1, we distributed a recruitment survey via email through the mechanical engineering department's student listserv. In the recruitment survey, students were asked to provide general demographic and background information. This provided the research team with an initial understanding of participant's perceptions of engineering program difficulty prior to the interview. To gain this initial understanding, we compared students' responses to two questions. The first was a multiple-choice question that asked, "How would you describe the difficulty of being an engineering student in your program?" that students could answer on a four-point scale of "very easy" to "very difficult". In the second question, students were asked to respond to the prompt "How would you compare this difficulty with your initial expectations?" with an open response.

Recruitment survey respondents were considered eligible for an interview if they met the following inclusion criteria: 1) currently enrolled in the mechanical engineering program at the host university, and 2) have completed at least one semester in that program. To capture a wide variety of student experiences, we purposely sampled interview participants by gender, academic level (i.e., first year, second year, third year, etc.), and their perceptions of engineering program

difficulty. A summary of participants and their indicated perception of program difficulty is shown in Table 1. To protect the identities of student participants, we do not include other demographic information.

Table 1: Participants Pseudonyms, Academic Year, and Perception of Program Difficulty.

Freshman (1st year)	Sophomore (2nd year)	Junior (3rd year)	Senior (4th year)
Andrew – Difficult	Benjamin – Difficult	Morgan – Difficult	Josh – Very Difficult
Kelsey – Difficult	Porter – Easy	Chase – Difficult	
	Sarah – Very Difficult		

In Phase 2, Smith and Kabir conducted interviews via Zoom virtual meetings. Each interview lasted approximately 35 minutes. Questions from the semi-structured interview protocol developed by the research team are listed in Table 2. All audio recordings of the Zoom interviews were transcribed by Authors 1 and 2. These transcripts were analyzed using an inductive, qualitative analysis technique and comprised of three iterations. First, we read through the transcripts to familiarize ourselves with participants' backgrounds and stories. During this initial review, critical events and experiences related to identity formation were identified and coded. Common codes included people and events that either promoted or hindered professional identity formation as well as the context in which the experience occurred (e.g., in a course setting, during an internship, etc.). Second, we used a constant comparison approach to relate established codes based on a rereading of each transcript. Coding relationships in the form of themes were continuously adjusted until all transcripts had been revisited and the members of the research team reached saturation and consensus. Lastly, the themes were reapplied by the research team to ensure applicability across participants. A summary of the data collection and analysis procedures is outlined in Figure 1.

Table 2: Sample Questions from Interview Protocol.

Why did you choose your major?
From your perspective, what does it mean to be a "good" student? Do you feel like you fit with the description that you described? Why or why not?
You take an exam in one of your engineering classes and receive a low grade on it. What is your reaction or your first thoughts upon seeing that grade? Why?
You take an exam in one of your engineering classes and receive a high grade on it. What is your reaction or your first thoughts upon seeing that grade? Why?
How much do you think your grades will impact your ability to be an engineer?
From your perspective, what are the traits and skills necessary for being an engineer? Do you consider yourself to fit this description? Why or why not?
Do you think of yourself as an engineer? Why or why not?
If you were able to go back in time to tell your younger self a piece of advice before pursuing mechanical engineering, what would you say?

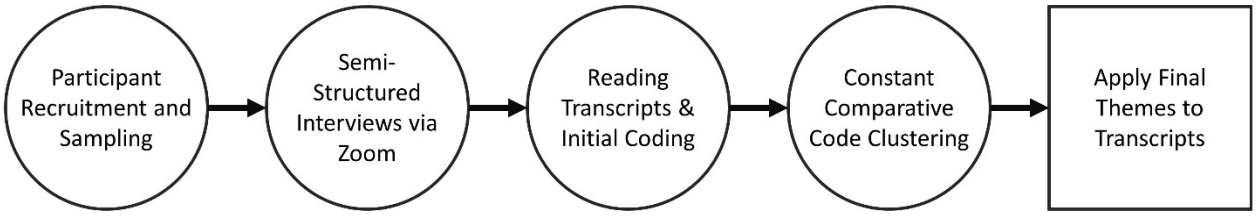

Figure 1: Summary of coding process.

Limitations

While this study provides insights into how students' interpretations of grades affect professional identity formation, the study has some methodological limitations due to the methodological choices we made during research design and implementation. We observed all of the recruitment survey respondents reported having an above-average grade point average (GPA), and as a result, our participant sample consisted of high performing students. This self-selection bias may have occurred for two reasons. First, these high achieving students may have been easier to access due to their summer employment positions such as working as an undergraduate research assistant or another position that requires them to regularly check their school email. Second, the interview procedures employed in this study inherently required students be comfortable with discussing potentially challenging experiences with course performance. We propose students who are not high performers may not wish to disclose such a sensitive topic to a researcher. To alleviate these challenges, we recommend recruiting students during the academic year, introducing the study to students in ways that ameliorate potential feelings of embarrassment, or provide alternative data collection methods (e.g., questionnaires), which allow students to discuss their experiences in a more discrete and potentially more comfortable environment.

Results and Discussion

Our exploratory qualitative analysis revealed insights regarding how students' interpretations of course grades influence their engineering identity formation and how those interpretations change over time. In Table 3, we provide a summary of identified themes for each research question and further describe these findings in the following sections.

Table 3: Research Questions and Identified Themes.

Research Question	Theme(s) Present
RQ 1: How do undergraduate students' interpretations of course performance influence the formation of their professional identities?	• Prioritizing engineering-related experiences and relationships as indicators of engineering identity • Being a student versus becoming an engineer
RQ 2: How do undergraduate students' interpretations of course performance change based on program experience (i.e., academic level)?	• Decreasing influence of grades as academic level increases

RQ 1: How do undergraduate students' interpretations of course performance influence the formation of their professional identities.

Two themes were identified that related to how students' interpretations of course performance influence the formation of their professional identities: (1) prioritizing engineering related experiences and relationships as indicators of engineering identity, and (2) being a student versus being an engineer. Together, these themes demonstrate the strategies participants used to interpret course grades as they made meaning of themselves as engineers. Our first theme, prioritizing engineering-related experiences and relationships, emphasized students' prioritization of engineering-related experiences over grades. When asked if she thought her grades would affect her ability to become an engineer, Morgan explained,

> I think before my internship, I thought [grades] would impact [becoming an engineer] a lot more. But through having an internship where I actually am, you know, being an engineer, I care about [grades] less. I feel like the impact is less, just because, you know, going into then what I've heard from both my employer and other employers, it's much more about like, how fast can you learn what you need to know on the job? Rather than, can you spit out all these equations that you did in school? So, I think grades are important for first getting into industry, you know, just being able to kind of get ahead of other employees and things, I guess, other hiring options. But being an engineer overall, and being in industry generally, I don't think [grades] really matter.

Andrew responded to this question in a similar way stating, "I think my grades won't necessarily impact my ability to be an engineer. The only thing that I think [grades] would really impact would be my ability to find a job or to continue in the program." In both Morgan and Andrew's explanations, they highlight the importance of grades for entering industry, but described grades as less important for becoming an engineer. Porter further expanded on this sentiment by stating,

> These classes right now are to teach us, you know, the basics of engineering. So, you know getting a B or some B's in classes or you know a C in a class here and there or you know even having to retake a class in the grand scheme of things I don't think [grades] will have a large effect or impact on you know being an engineer in the future.

While this theme was repeatedly identified throughout every participant interview, we also observed participants explicitly differentiated between their identity as a student and their identity as an emerging engineer, which we captured in theme 2. When asked if they considered themselves to be engineers, each participant provided their own unique perspective. Morgan responded:

> I do. Um, I think that's a lot to do with the fact that I have interacted in the professional industry more. I don't know if I would have said that even just a semester or so ago. But now that I've had experience working with other engineers, like in industry, and working on like engineering projects, I do

> consider myself an engineer already." Morgan clarified she only currently identifies as an engineer because of her work with other professional engineers.

In her explanation, Morgan clarified she only identifies as an engineer because of her work with other professional engineers, thus separating her engineering identity in the workplace from her student identity in college. Josh shared a similar perspective, "...At the moment, I think I think of myself more as a student. Like outside of school, I consider myself more of an engineer, I find myself thinking like an engineer more than I had before." When asked if good grades or receiving a degree defines becoming an engineer, Andrew's response to this prompt corroborated Josh's comments when he stated, "I would say it happens outside of [grades] for sure."

These quotes from participants underscore the role of context and identity salience [13], emphasizing becoming an engineer happens outside of school. Together, these two themes indicate the participants in our study made more meaning out of themselves as engineers through engineering-related experiences such as participating in co-op and internship opportunities outside of school and relied less on grades or formalized academic feedback. However, this is not to say grades are unimportant in becoming an engineer. For Porter, becoming an engineer does not happen until after college, "I really don't consider myself an engineer just because I guess that's the title reserved, you know, after you've graduated, after you actually start work." While he does not explicitly link becoming an engineer to grades, he does acknowledge a degree is needed to start work as an engineer, which highlights the continued tension between grades, engineering identity, and what being an engineer means.

RQ 2: How do undergraduate students' interpretations of course performance change based on program experience (i.e., academic level).

In relation to how students' interpretations of course performance change over time, we found a qualitatively decreasing influence of grades as academic level increased based on participant interviews. In some instances, participants walked us through a diminishing emphasis on grades from when they were in high school and into college. When asked about his thoughts on the importance of grades, Andrew shared, "So, in high school, I definitely thought of my grades as a way to get into college, to get scholarships and stuff like that. But now that I'm here in college, I've I don't know, I guess I don't really place as much focus on my grades." As Andrew describes, grades serve as a requirement to enter college and apply for scholarships, but once he had achieved those necessary steps, grades did not have the same level of importance as they did before. He continued:

> I mean, I still care about them a little bit, but I'm not checking them, like once a week, like I was in high school, making sure that my grades are still out there. But I do still kind of think about it and think about like, hey, how am I doing in this class? I kind of use it more as a gauge of am I studying enough? Am I putting in the work that I need to?

As Andrew progressed in his academic career, his use of grades shifted from being a tool to get into academics into a tool used to help him gauge the effectiveness of his strategies (e.g., studying) for moving through his courses in pursuit of his degree. Chase echoed Andrew's

sentiment that once the stress of scholarships was gone, grades began to not matter as much as they had previously,

> I don't stress as much about the grade average anymore. My scholarships that rely on grade averages ended, so I'm not too stressed about it as much. [. . .] It's more about trying to keep up with the different classes all kind of piling on to each other and the biggest part is trying to keep track of you know the five different subjects that I'm trying to learn and the there are various assignments and tests that are coming up as well as like study groups and recitations and trying to appropriately go to these things that'll help me manage the workload but that also kind of adds to the cluttering of my time.

As they continued in their undergraduate programs, participants were required to manage multiple aspects of their professional development including higher course loads, more difficult content, differing schedules for course projects, applying for positions, etc. From this perspective, school became something to get through and the importance of grades was diminished.

Mediating Expectations

Overall, these findings point to a larger theme of mediating expectations in engineering education. We conceptualize mediating expectations as the shifting of students' definitions of what being an engineer means, what "counts" as engineering, and when one becomes an engineer. Within this particular study, as participants increased in academic level, their reliance on grades tended to decrease. As demonstrated in RQ1 theme 1 and findings from RQ2, we propose that as students were exposed to more engineering-related activities and people, such as those that mimic full-time employment, their expectations of engineers as high academic performers changed. These findings align with those of Araiinejad *et al*. [14] and McCall *et al.* [9] and may be further explained by Tonso [15] in which she breaks down the broad sociocultural characterization of engineers as nerds and high achievers/performers. Her work explicates the nuance of various social categorizations with engineering itself, indicating as students become more familiar with engineering educational culture, the more personalized their definitions of engineering become, including a deemphasis on the role of grades as a marker of engineering formation.

Conclusion and Implications

The findings reveal more questions than answers. In this exploratory study, we began to unpack the general trends of how students' interpretations of grades influenced their formation of engineering identities and how those interpretations changed over time. In general, students tended to discuss other sources of identity formation such as participation in co-ops and internships as well as interacting with professionals related to these contexts. However, due to the already high-achieving nature of study participants, topics we anticipated to come up, such as those related to mental health, were not something that was discussed. Future work will include conducting the same interviews with students from a variety of achievement levels and socioeconomic background to get a more nuanced understanding of these groups of students and

gain a greater understanding about how grades may or may not influence students' identity formation as engineers.

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