Full Paper: Examining first-year students' nascent disciplinary identities and epistemological orientations

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Introduction

Engineering identity has become an important lens through which engineering education research has sought to understand students' disciplinary motivations and subsequent persistence in related curricular programs. This research has had significant implications for retention of underrepresented populations in the STEM fields, as campuses continue to explore ways to equitably support an increasingly diverse student body [1], [2], [3]. For example, Doran and Swenson's [4] study examined the connection between retention and belongingness for students from academically at-risk populations, revealing that the stronger a students' engineering identity, the greater their chance of persisting in their engineering program. Similarly, Melo et al.'s [5] study explored the lack of recognition multilingual students felt as engineering students, consequently impacting their identity development. Studies like these are particularly important in for learning how to better support students from minoritized and underrepresented backgrounds.

There are limitations, however, in their applicability of identity theory particularly where it comes to understanding young students' articulation of identity and the ways in which identity is narrowly operationalized. Specifically, these studies often rely on quantitative or mixed methods that, while valuable, only reveal part of students' developing engineering identity. This limitation is of particular concern when investigating young students that are new to the study of engineering. To address this gap, this study explores the nascent disciplinary identity development of engineering students to better understand what dimensions of engineering identity are apparent for students as they start university. Through qualitative interviews and discourse analysis, this study argues that epistemological orientations, or specific ways of knowing, are also central to understanding how first-year engineering students' identities are constructed and maintained.

Operationalizing Engineering Identity

Among the studies on STEM-related disciplinary identity, Carlone and Johnson's [6] study and Hazari et al.'s [7] study have been influential in laying the groundwork through their development of a framework identifying several factors contributing to engineering identity. This framework, further elaborated upon in Godwin et al.'s [3] study, forwards that engineering identity is comprised of three main dimensions: (1) interest in the specific subject; (2) performance/competence or student self-efficacy in a subject; and (3) recognition or student perception of how others see their abilities, participation, and affinity to the subject. In their study on women in engineering, Godwin et al. [3] pay special attention to the role that recognition beliefs play in identity development, finding that recognition had the largest influence on student identities.

The notion of recognition also factors heavily in Gee's [8] conceptualization of identity as an analytical lens for educational research. Indeed, many of the above studies cite Gee's [8] approach to identity as a basis for much of their investigations. Gee conceptualizes identity as

this recognition of being a "certain kind of person" [8, p. 99] and further argues that much of this recognition work is enacted discursively, through conversation and dialogue. Gee's [8] focus on discourse identity highlights the storied nature of identity maintenance and thus aligns closely with narrative approaches that focus on participants' narrative retelling of experiences as key sites of identity negotiation. Through these narrative retellings, participants make sense of their experiences thus contributing insight into how identities are sustained.

These notions draw close connection to Lave and Wenger's [9] work on situated learning which describes identity as a process developed through contextualized practices. They argue that it is through the situated learning within specific contexts and communities that one learns to be a certain kind of person. Taken together, identity is thus maintained through discourse and narrative in achievement of recognition as a certain kind of person.

Young students who are still in the process of developing a disciplinary identity may be less aware of their developing identities and as such, survey-based approaches that engage students in active exploration of their identity are limited. This paper argues that it is through examination of their talk about their interests, abilities, and curricular practice that we can better understand how their identities are formed. Several studies have qualitatively examined how recognition beliefs play a role in their identity construction, contributing much to our understanding of engineering identity [1], [2], [5]. These qualitative approaches, however, remain scarce. This current study aims to contribute to this need for qualitative examinations of how students actively negotiate their identity through communication of their experiences.

This study relies on Gee's [8] notion of discourse identity and Lave and Wenger's [9] emphasis on identity formation through situated practice as a lens for examining how students communicate their nascent disciplinary identities. Further drawing upon the framework forwarded by Godwin et al. [3], this study operationalizes identity as students' discursive construction of interest and competence in engineering and that through this discursive articulation, students negotiate their recognition as engineering students.

The research questions guiding this study are:

1. What dimensions of engineering identity emerge from students as they talk about their academic experiences in high school and in their first-semester of college?
2. What factors influence how students construct and articulate this identity?

Methods

Data in this study are part of a larger project exploring students' academic experiences as they transition from high school into their first semester of university. The study was conducted at a small-sized STEM and design focused university in New England in Fall 2023. Recruitment invitations were sent to students via their first-year math courses, thus expanding the potential volunteer pool to the entirety of first-semester university students regardless of major. Sixteen first-semester students volunteered to participate in this IRB approved study. Participants in the study represented students from both engineering and architecture programs of study. Students at this university begin their first-semester with declared majors.

Semi-structured hour-long interviews were conducted with each of the participants. These interviews focused on exploring students' academic experiences in their high school as well as their first semester of coursework. As semi-structured interviews, students were initially asked broad questions about their classes across these contexts such as, "Can you share what kinds of classes you took in high school? What were they like?"; where applicable, participants were subsequently invited to expand on those experiences through questions like, "Tell me more about your experience in [said class]."

Each interview was transcribed, and transcripts were reviewed for accuracy. Each transcript was subsequently analyzed to identify narratives of engineering identity construction. Identity was operationalized as discursive talk of disciplinary practice and in alignment with Godwin et al.'s [3] dimensions of interest, performance/competence, and recognition. Subsequent analysis aimed to address the research questions by providing rich description of these orientations to examine if any additional dimensions emerged and the factors that influenced this identity development.

Analysis of discursive talk around interest, performance/competence, and recognition revealed an additional component to students' narratives. As students elaborated on their experiences, they inherently evaluated their experiences, evaluations which were often based on nascent perceptions of how they believe engineering learning happens. These evaluations are important locations of identity construction because they reveal what students value. As such, through iterative analyses of student narratives, particular attention was paid to how and where students communicated their evaluations of engineering learning and of being an engineer.

Findings: Epistemological Orientations and Hands-on Learning

Students' narratives that describe their interests and orientations toward engineering are embedded in the stories they retell about their experiences with coursework and beyond the classroom [8]. Cursory examination of the narratives in this study suggests a diverse range of experiences; and yet, closer analysis reveals a particular throughline across these narratives. Specifically, many of the participant students relied on the notion of "hands-on learning" to frame an evaluation of their experiences as young engineers. Of the sixteen interviewees, at least half used the exact phrase "hands on" while an additional three relied on similar phrasing to describe what they understood to be good learning as an engineering student. To illustrate this significance, interview excerpts are shared and analyzed below. For the purposes of conciseness three excerpts are shared as representative samples of the larger data set.

Because engineering identity is operationalized as the discursive construction of one's interest, competence/performance, and recognition, it is important to examine how these dimensions emerge through talk of one's experiences. The transcript excerpts are presented as dialogue to preserve the interactional nature of discourse in action. "R" represents the researcher, the author of the study who is also conducting the interviews, while the other initials represent pseudonyms of the participant students.

Cohen (C) is a mechanical engineering major who attended a high school that he described to have a project-based curriculum. In the following excerpt, he shares how he had always been interested in engineering through descriptions of his childhood and hobbies.

C: I'm majoring in mechanical engineering. I don't quite know how to put, like, how I got into it. I, I was just always one of those kids that loved engineering, you know, from, like, a very young age. I was, like, on the engineering track. I was always doing like, I was one of those kids; I would build. Like, I think when I was eight, I would like, convince my parents to buy you like $300 Lego sets meant for me that have like 18+, you know, it's like 4000 pieces. And my bedroom floor would just be a Lego workshop for like a week or two.

R: And this is what kind of led you to the engineering path?

C: Yeah, just. I love, like, disassembling things, learning how things worked. One of my favorite TV shows was that show "How it's made." Yeah. So I just kind of loved that and learning how things worked. So I just kind of loved that and learning how things worked. So that was kind of like, I don't know, a progression of mine throughout life. Like there's something I've always been interested in.

R: Did that influence the high school that you chose to go to?

C: Yes. But also partially, I feel like there are a lot of other aspects. Definitely, like having the ability to, like, work with my own hands and, like, build fun little projects made it a lot more interesting.

The excerpt reveals the breadth of contexts across which Cohen's engineering interests span. His interests began in childhood and influenced how he spent his leisure time. Through his talk of his interests in Legos and television programs, he is establishing an identity as someone who likes to work with their hands and this identity is ultimately tied to his understanding of what it means to be an engineering student. This is most evident in the conclusion of this excerpt when he is asked to talk about how he chose to go to a high school with a project-based curriculum. He emphasizes the notion of "working with my own hands" as central to a successful learning process for him. Thus, hands-on learning is not only part of Cohen's understanding of his interest in being an engineer, it is also central to the situated practices of a discipline and even more importantly how one learns to be an engineer. This epistemological orientation is particularly impactful in the nascent development of disciplinary identity.

Being "hands on" is similarly central to Emily's interest in engineering, an orientation that she contrasts with her experiences in her English classes. Emily, who is an engineering major, understands her successes in an engineering class in high school as a counterpoint to why she does not find English as interesting. In the following excerpt, Emily had just listed several of her high school classes and was asked to expand upon her experience in these classes.

R: Talk about English and your Tech Ed classes.

E: In English, I don't see something really tangible coming out of it, but with woodworking, yeah I build an Adirondack. I'm into the hands on of it. But with English, there isn't a tangible outcome, writing an email, learning how to do that is beneficial, but it doesn't keep my mind occupied. Yeah I can do it, but it's not something interesting. I've always been more hands on. That's why I like [this university], because there's the more hands-on aspect, it isn't just the first two years where you get your general education, you have the applications immediately, I like that.

When discursively communicating identity, explicit attempts to establish oneself as one type of person by contrasting one's identity to another identity is a central way of bidding for recognition. Perhaps more interesting is how Emily's own attempts to establish her recognition as an engineer are crouched in more dominant narratives that are repeated in broader culture—the dichotomies between sciences and humanities and the related ways of knowing that bind experiential learning with the STEM disciplines. Emily explicitly expresses a disinterest in English and subsequently correlates her interests to subjects that are more hands on. The opportunity to be hands on led her to majoring in Engineering (which she describes in other parts of her interview) but more specifically here, the reason she chose this university. Her reliance on 'hands on' as a specific learning preference can be seen as a clear bid to seek recognition as a kind of student, an engineering student that appreciates a "tangible outcome." Being an engineer thus is inextricably tied to a specific form of situated practice.

In this third excerpt, Hannah (H) describes her dissatisfaction for one of her current engineering classes, an evaluation she connects to a lack of "hands-on" learning. Similar to Cohen and Emily, Hannah is an engineering major who first became interested in engineering through coursework she had in high school.

R: How are your [engineering classes] like?
H: I just wish there was maybe more hands-on work or more like real life situations. But it's also our freshman first semester, so
R: So you wish there was more hands-on like stuff. What do you mean by that?
H: I'm not sure if it's just because it's general engineering where they walk into each different discipline in our engineering lecture classroom, basically just sit there and listen to like, Oh, that's what it means to be an engineering student. But I feel like maybe there should be more instruction. I'm like, might actually try to do stuff rather than just learning what it means to be one.

In the dialogue above, Hannah is making sense of what learning to be an engineer means. Her negative evaluation and dissatisfaction with her current engineering class signifies not only a personal preference for hands-on learning but rather a tacit understanding that learning to be an engineer requires hands-on learning. Seen most clearly when she states, "…might actually try to do stuff rather than just learning what it means to be one," Hannah describes an epistemic orientation where being an engineer means participating in certain kinds of situated practices.

Discussion and Implications

In exploring the dimensions of engineering identity as students talk about their academic experiences in high school college, several key findings emerged. Firstly, it became quickly apparent that for these students, their disciplinary identity formation began in high school and continued to develop through specific classroom tasks and activities. This contrasts Godwin et al.'s [3] claims that students come into college with no experience with engineering. While students' identities are indeed still developing and undergoing change, their high school experiences have shaped how they understand what it means to be an engineer. This is perhaps most apparent in the dialogue from Hannah, where her evaluation of her current engineering class is rooted in her pre-existing notions of what learning in engineering should look like.

In addition to gaining a broader picture of students' engineering identity across the transition from high school to college, the findings from this study reveal how identity is learned through and rooted in situated practice. Identity is thus more than just the connection between interest, competence, and recognition, but rather underscored by a clear epistemological orientation. This paper argues that this key distinction is of paramount importance when investigating students' engineering identity, an identity that centers hands-on learning as a core tenet to engineering education.

For the lay reader and pedagogue alike, the centrality of hands-on learning in engineering education may seem an obvious, even banal finding. However, hands-on learning as an additional or underlying dimension of engineering identity in fact problematizes "interest" as a one of the main dimensions of engineering identity as set forth by Godwin et al.'s framework [3]. Interest as a dimension of identity suggests that there is an inherent interest in a core subject. The excerpts above suggest that students are ultimately interested in engineering because of *how* it is learnt in addition to *what* is being learnt. This has significant implications for engineering educators in both high school and college contexts. If motivation is connected to engineering identity development, then how students engage with the subject can become a primary means for fostering that development.

This epistemological orientation also has implications that reveal potential limiting factors in creating education opportunities. For these students, being "hands on" was more than just a way of learning the subject; it was central to the experience of being an engineer. And clearly, these orientations were learned early on. But by maintaining this orientation, students may inadvertently limit their opportunities to explore alternative ways of learning the same subject matter, or even learning other subject matters. This was evident in both Hannah and Emily's excerpts where positive and negative experiences where both crouched within clear epistemic ways of knowing.

Seen another way, their epistemological orientations may simply be reifications of broader disciplinary discourses. The persistence and prevalence of the specific phrase "hands on" may be just as representative of personal orientations as it is indicative of the language institutions rely on to represent their own fields. As such, it is crucial to consider the relationship between the broader disciplinary narrative frames that influence how we teach our students, for it is these very frames that shape the epistemological orientations through which these students articulate their own identities.

Limitations and Future Research

Self-selection bias is a contributing limiting factor to many studies based on volunteer recruitment. Academically successful students with more established disciplinary identity constructions would potentially be more willing to share their experiences; this study is no exception. Future research can target specific populations to examine if identity construction is similarly epistemologically oriented. More importantly, by expanding the recruitment scope to consider additional demographic factors, future research could further examine how to better support students from minoritized and underrepresented populations.

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