# Threats to undergraduate student identity development in interdisciplinary undergraduate research settings

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**Abstract:**

Students entering interdisciplinary programs often encounter uncertainty regarding the legitimacy of their chosen field, ambiguous degree nomenclature, and unclear career pathways which can obstruct the development of a coherent engineering identity. A key contributing factor for these challenges is the misalignment between traditional conceptions of engineering and the evolving nature of work within these emerging domains. This paper presents findings from a longitudinal qualitative study examining the evolving identity formation of two undergraduate students engaged in a long-term undergraduate research experience at an R1 university, totaling six interviews with the two students over 9 months. The students are engaged in highly interdisciplinary research related to energy and sustainability, though their academic major is not typically considered core to energy conversations. Through lenses of engineering identity and academic literacies theory, an inductive thematic analysis showed oscillating evolution of participants' self-perceptions as engineers as they gain research experience. Findings highlight significant structural and cultural barriers testing identity development. Here, we employ the terminology of "culture" to include both engineering culture and disciplinary culture, which governs language patterns, values, and self-perceptions. Some notable concerns were a lack of standardized language for skills and roles, insufficient visibility of interdisciplinary fields within mainstream engineering discourse, and a perceived disconnect between interdisciplinary academic training and industry expectations. Our findings highlight a fascinating tension: While involvement in authentic undergraduate research reinforces participants' engineering identities by increasing their sense of competency, at the same time, these students feel uncertain about how interdisciplinary domain knowledge "fits" within their traditional discipline or the broader ecosystem of engineering, causing a sense of marginalization, and amplified uncertainty about post-graduate opportunities. This paper highlights the need to reevaluate how professional development and advising strategies may be altered to better support the identity development of undergraduates in emergent and interdisciplinary disciplines or research experiences.
**Keywords:** engineering identity, interdisciplinary, undergrad students, researchers

## Introduction:

Engineering as a discipline continues to evolve in response to increasingly complex societal and technological challenges. Many emerging engineering domains draw heavily on multiple knowledge bases and require practitioners to integrate diverse technical, scientific, and applied skill sets [1], [2], [3]. The working definition of interdisciplinarity in engineering states that there is some level of integration between interacting fields of expertise [4] (unlike *multidisciplinarity*, where interactions are less likely to employ integrative processes, and the individuals involved do not necessarily learn from other disciplinary perspectives [5], [6]. Despite the tangible applications of interdisciplinary fields, universities frequently encounter difficulties recruiting students into such programs, and prospective students often lack awareness or understanding of the field before entering higher education.

These challenges are consistent with broader issues documented across interdisciplinary engineering programs. In many cases, educators themselves find it difficult to communicate and correlate between different academic disciplines and their specific practices and culture [7], [6]. Some challenges are pedagogical: it becomes difficult to incorporate all disciplines smoothly alongside designing interdisciplinary tasks [8], [9]. Such conditions may disrupt students' identity development, limit their sense of belonging, and obscure their understanding of what it means to be an engineer within an emerging domain. At the same time, industry stakeholders continue to report shortages of engineers prepared for complex interdisciplinary roles, underscoring a persistent misalignment between workforce needs and educational preparation which can be met by having a diverse engineering population ready to lead in a changing world [1].

Although these issues are recognized in national discussions on engineering workforce development, empirical research that centers the lived experiences of students enrolled in interdisciplinary engineering programs remains limited. Little is known about how students in fields such as Agricultural and Biological Engineering interpret their disciplinary positioning, navigate institutional expectations, and understand their place within the broader engineering community. This lack of insight constrains efforts to address low enrollment, limited diversity, and comparatively high attrition in these fields. This paper seeks to contribute to this gap by examining the experiences and perspectives of undergraduate students within Agricultural and Biological Engineering, with attention to how disciplinary ambiguity and program structure shape their educational trajectories and emerging engineering identities.

## Literature Review:

Public perceptions of engineering have become a central focus of research due to their substantial influence on student recruitment, retention, and the overall diversity of the engineering pipeline. Messaging about who engineers are and what they do shapes not only the decisions of prospective students but also how current engineering students interpret their own abilities, belonging, and long-term fit within the field [10], [11], [12]. A consistent finding across decades of research is that engineering is often associated with narrow, technical, and mathematically rigid stereotypes that fail to capture the breadth, creativity, and social relevance of modern engineering practice [13], [14], [15], [16]. Numerous studies highlight the persistent stereotype of engineering as another reason for the distinct gap in representation in the field. Students from groups that have been historically marginalized in engineering contexts may be more sensitive to messaging around competence and belonging and have difficulty identifying themselves within engineering disciplines [17].

These perceptions are embedded deeply [18]. These longstanding cultural stereotypes continue to shape perceptions today, with engineering often portrayed as inflexible, masculine, and technologically deterministic [19]. Significant national efforts have been made to address these issues. *Frontiers of Engineering: Reports on Leading-Edge Engineering* revealed that despite heavy investment, public understanding of engineering had scarcely improved [20].

In response, the National Academy of Engineering launched the *Changing the Conversation* initiative in 2008 [21, p. 200]. This report found that students held inaccurate assumptions about engineering, including beliefs that engineering work was sedentary, isolated, and conducted primarily on computers with little human interaction. Research consistently demonstrates that students are more likely to enter and persist in engineering when they align with messages highlighting creativity, societal impact, collaboration, and opportunities to help others [21], [22], [23].

As engineering disciplines expand, public messaging has failed to keep pace. "New" engineering fields such as biomedical, environmental, agricultural, and biological, are increasingly interdisciplinary and collaborative. They have a high impact on addressing societal issues in medical, environmental, and agricultural contexts. Yet popular imagery continues to center a narrow archetype of the engineer as a "math-solving" individual [24], [25] and typically male [26] , which reinforces exclusionary conceptions of engineering work and identity [21]. Research shows that this mismatch between actual engineering practice and external messaging contributes to uncertainty among students in interdisciplinary majors, who often struggle to articulate their identity or explain the relevance of their field [27].

For agricultural and biological engineering specifically, the complexity of the discipline and its blend of biological sciences, sustainability, technology, and systems engineering can be difficult for prospective students to understand. Messaging that frames engineering only through mechanics, physics, or computational work obscures the interdisciplinary nature of the field and limits its visibility in both K–12 and higher education recruitment efforts [21]. Expanding public understanding of engineering to reflect the interdisciplinary, human-centered, and socially impactful nature of modern engineering is critical for aligning societal perceptions with the realities of contemporary engineering practice.

Limited literature has focused on the experiences within engineering disciplines, especially these highly interdisciplinary and non-traditional fields. However, understanding the experiences of interdisciplinary engineers and engineering students is essential for assessing how they are received within academic environments and the engineering workforce. Higher education typically organizes engineering programs according to disciplinary subject matter (e.g., mechanical, electrical, biomedical), whereas engineering firms tend to classify roles according to work functions, competencies, or project-based demands [3]. This uncertainty may weaken confidence in degree choice and contribute to reduced persistence compared with more established engineering majors [6], [27]. As interdisciplinary engineering roles continue to expand in response to complex global challenges, it becomes increasingly important to understand how students navigate identity, belonging, and career clarity within these emerging domains.

The paper seeks to answer the following research questions:

- **RQ1:** What obstacles do interdisciplinary engineering undergraduates encounter that negatively influence the development of an engineering identity?
- **RQ2:** What factors mitigate these obstacles and support engineering identity development for interdisciplinary engineering undergraduate students?

## Conceptual Framework: Engineering Identity

Engineering identity has become a central construct in engineering education research because of its strong associations with students' motivation, self-efficacy, sense of belonging, and persistence in engineering pathways. Identity-based frameworks provide explanatory power beyond traditional academic measures, allowing researchers to examine how students come to see themselves as engineers and how social, cultural, and institutional structures reinforce or undermine this process [28], [29], [30].

Godwin's Recognition-Competence-Interest (RCI) framework is one of the most widely used models for conceptualizing engineering identity. The framework posits that engineering identity develops through the interaction of three interrelated components: recognition, or the degree to which students are acknowledged by others (peers, faculty, mentors, family, professional communities) as legitimate contributors to engineering; competence, or students' beliefs in their ability to understand and perform engineering-related tasks; and interest, or the intrinsic motivation and desire to engage with engineering content and practices [23]. Empirical studies have demonstrated that students who persist and thrive in engineering tend to exhibit stronger engineering identities across these dimensions [23], [31], [32].

Despite the robustness of the RCI framework, its application has been concentrated primarily in traditional engineering disciplines such as mechanical, electrical, civil, and chemical engineering. Much less is known about how engineering identity develops among students in interdisciplinary or emerging engineering fields. Research suggests that interdisciplinary students navigate unique challenges, including ambiguous disciplinary boundaries, limited visibility of the field, evolving curricula, and inconsistent recognition from peers and faculty

[6], [27]. These structural and cultural factors may complicate the formation of a stable engineering identity and influence students' academic trajectories and career decision-making.

This theoretical approach is particularly relevant for understanding fields such as Agricultural and Biological Engineering, where disciplinary ambiguity may influence students' confidence, sense of legitimacy, and long-term engagement. By situating this study within the RCI identity framework, we aim to illuminate how interdisciplinary engineering students experience recognition, develop competence beliefs, and sustain interest, and how these factors collectively shape their persistence and career intentions.

**Methods**

This study is embedded within a larger National Science Foundation (NSF) funded undergraduate research program at a R1 institution in the northeastern United States [33]. The broader longitudinal program supports undergraduate students who conduct energy-related research across university laboratories.

The present paper focuses on two participants whose experiences differed substantially from the rest of the cohort. Both students were the only representatives from Agricultural and Biological Engineering, an interdisciplinary field that contrasts with the more traditional engineering majors represented in the program. Although the sample consists of only two participants, this size is appropriate for a longitudinal, in-depth qualitative study. "Small-N" qualitative designs support intensive engagement, repeated interviews, and close tracking of identity development across time [34]. For the purposes of participant de-identification, all participants in this study are given gender-neutral pseudonyms and will be referred to via they/them pronouns regardless of gender identity.

The two focal participants were interviewed three times between January to September 2025. Semi-structured interviews took place at the beginning and end of the spring semester and again at the beginning of the fall semester after the students returned from summer internships or work experiences. Initial interview protocol development was guided by Godwin's Recognition, Competence, and Interest framework of engineering identity [23]. Iterative engagement with early transcripts revealed additional patterns related to interdisciplinary identity formation, leading to subsequent protocols with more reflective questions tailored to their experiences. All interview audio was transcribed and manually cleaned by the first author. Data analysis followed an abductive thematic analysis approach. Transcripts were initially coded using deductive codes derived from the engineering identity framework, and inductive codes were added as new concepts emerged. The codebook underwent several iterations before being applied systematically to all transcripts.

After coding was completed, themes were synthesized and organized into conceptual categories employing inductive, theory-driven methods of open- and axial- coding. For interpretive clarity, the final themes were grouped using an analytic metaphor that distinguishes factors that reinforced engineering identity (referred to as Drivers) from factors that impeded or destabilized identity development (referred to as Speedbumps).

This study is limited by its small sample size and single-institution context; however qualitative research centers transferability, such that even small sample sizes provide knowledge that can be transferred to other contexts and participants who may be experiencing similar issues. While focusing on Agricultural and Biological Engineering provides depth in an interdisciplinary context, we acknowledge that these specific details may not reflect experiences in other specific engineering domains. Finally, while the longitudinal design captures evolving identity dynamics, findings are illustrative of processes rather than representative of all undergraduate engineering students.

## Findings

This section presents findings organized into two analytic code sets, labeled 'Drivers' and 'Speedbumps'. The Drivers codes align with components of the Godwin RCI framework and as expected, were associated with increases in confidence, motivation, and identification with engineering. However, these positive influences were frequently counterbalanced by participants' perceptions of engineering culture and disciplinary norms. For students situated in interdisciplinary engineering contexts, these perceptions often reduced their sense of legitimacy and belonging.

These tensions are captured within the Speedbumps codes, which illustrate how narrow definitions of engineering, unclear disciplinary boundaries, and cultural expectations can erode engineering identity even in the presence of strong motivational drivers. Together, the Driver and Speedbump codes highlight the dynamic, and sometimes conflicting, processes that shape engineering identity development for undergraduates engaged in interdisciplinary research experiences.

Table 1: Codes and definitions

| Drivers (Motivation Builders) | | | Speedbumps (Perceptions of Engineering) | |
|---|---|---|---|---|
| Codes | Definition | | Codes | Definition |
| Relevant Experience | Participation in formal (internships, research) or informal (family business, applied projects) engineering experiences. | | Imposterism fed by perceived disciplinary rigidity | Not feeling like an engineer due to conflict with the rigid perception of engineering work, or mismatch with stereotypes. |

| | | | | |
|---|---|---|---|---|
| Purpose-Driven Interest | Motivation rooted in seeing research or work outcomes make meaningful impact alongside alignment with long term career goals | | Values and Identity Misalignment | Conflict between personal values and cultural stereotypes of engineers as rigid or socially detached. |
| External Recognition and Validation | Positive feedback from advisors, mentors, or supervisors that reinforces competence and belonging. | | Lack of academic and professional recognition | Poor perception of institutional structural barriers and engineering professional expectations |

**Drivers**

1. Relevant Experience and its impact on student competence

Both participants described substantial early exposure to STEM environments, which prior engineering identity research identifies as a strong predictor of early interest, perceived competence, and likelihood of identifying as an engineer. Family involvement in engineering or related work served as an important source of early identity support. As one example, Terry described multigenerational family involvement in engineering and science that normalized engineering as an attainable and expected pathway from a third-generation engineer in their family. In addition to family influences, Terry described extensive pre-college experiences with building, robotics, and hands-on technical projects, which further reinforced perceived competence and familiarity with engineering practices which only strengthened with their multiple formal experiences in internships and projects. These experiences fed their early competence development and sustained motivation during dissatisfaction with coursework: *"I've enjoyed doing research so much because I was able to learn on my own terms. So, working on research projects kept me in engineering when I really hated the classes. Because I know that the classes are not what engineering actually is... so that was encouraging."*

Dakota, our other participant, described growing up on a farm and working in a family-owned farm equipment dealership, which fostered familiarity with agricultural systems, shaping an initial academic pathway, and later prompting a transition into an interdisciplinary program integrating engineering and agricultural sciences. Despite their extensive informal experience, Dakota viewed these experiences as "less technical" than peers' traditional engineering internships or coursework. From an engineering identity perspective, this reflects a gap between actual and perceived competence, shaped by culturally dominant definitions of legitimate engineering work.

This perception shifted during a summer internship with an agricultural engineering company. Dakota described increasing identification with engineering through exposure to formal practices and proximity to credentialed engineers: *"I think every time we have a meeting it's a little more like I lean towards feeling like an engineer with every single one of these meetings, because I'm getting more experience within research and my internship, and especially because I'm working so close with like the field test engineers. I think that is definitely helping me feel like more of an engineer."* After completing the internship, Dakota linked the experience to increased confidence in future employability: *"I feel like it gave me a better chance into getting an engineering position, like a test engineering position for a machine manufacturing company, which is really something that I want to be doing. Yeah. So, I think it kind of boosted my chances of that."* The structured and externally validated nature of this experience functioned as a strong driver of engineering identity development by reinforcing perceived competence and professional legitimacy.

Taken together, these accounts suggest that both Dakota and Terry entered their undergraduate programs with conditions associated with strong early engineering identity, including early exposure, mentoring, hands-on experience, and familial validation. Across both participants, practical experiences strengthened engineering identity only when interpreted as legitimate within prevailing engineering norms. Informal agricultural labor and certain academic achievements were frequently discounted, demonstrating that even seemingly "relevant" experiences (to an outsider) may not always translate into increased perceived competence or a stronger engineering identity.

2. Purpose Driven Interest

The participants demonstrated strong, sustained interest in agricultural engineering and their research activities. Prior engineering identity literature highlights domain-specific, personally meaningful interest as a critical contributor to retention and long-term identity development [22]. Dakota described a personal investment in research connected to challenges on the family farm. This alignment between background and research outcomes gave their work a strong sense of purpose: *"…decarbonization on campus is one thing. But like from my background in agriculture, we're trying to be Net-Zero [Carbon emissions…. So, it's kind of important to me."* Over time, they described how engagement in purpose-driven research strengthened their confidence and reinforced the meaning they ascribed to their work: *"I feel like it makes me even more confident that I have a purpose in what I'm doing, and that I'm helping other people, and helping farmers, and helping the company."* Dakota's interest guides their future goals, and they actively seek opportunities to build skills and position themselves as an attractive candidate: *"I'm enjoying what I'm doing [intern position], but I don't think I would want to do this as a career. I think I'd like to try more of the technical equipment. So, what a field test engineer would be doing."*

Similarly, Terry expressed strong motivation rooted in the perceived impact of their research and its connection to place-based identity. Their interest in engineering was closely tied to contributing to the region they consider home and addressing land-use challenges they care deeply about: *"... with this program specifically, it's applicable to [the university] like I've grown up in this place, this valley is my home. And so, it's important to me, I care about land use"* Terry extended this purpose beyond research into teaching and curriculum development, framing the work as a meaningful extension of their engineering identity: *"I am working to redo the curriculum for one of my classes next so exciting. And I'm working that out."* Regarding future aspirations, they prioritized an interdisciplinary path in education, combining scientific and engineering skills while pursuing communication and learning opportunities: "I feel like I'm a scientist who's good at doing engineering things, not an engineer who likes to do science things. Science education is a great way to connect all those things, because you're always learning about something new, and you're forced to communicate about it."

Across both participants, purpose-driven interest functioned as a key motivational driver that sustained engagement in engineering-related work. While this sense of purpose did not fully resolve other identity challenges, it provided a stable foundation that supported persistence and reinforced the personal significance of their engineering trajectories. In both participants, their interest guided their future aspirations. Both the participants have given their future a significant amount of thought and are actively taking steps in order to reach their desired careers. This code shows that the participants are evaluating the value of the experiences they are involved in against what will help them the most with their future aspirations. They also demonstrate how this envisioned future career then becomes a motivation to seek out desired experiences.

3. External Recognition and Validation

Dakota talked about the positive reinforcement from their internship boss and research advisor that made them feel more competent and fight the insecurity or imposter syndrome feelings: "Especially*, like, being compared to other interns that were in the company. My boss told me that he was conversing with other bosses at different locations in different states, and they were saying, like, wow. I wish we would have had Dakota in our team, so that made me feel, like, really great…. He said it was like a breath of fresh air. I didn't have to teach someone else how to do it."* Another significant factor in boosting Dakota's engineering identity was having a capstone project as part of their curriculum. This made them feel like more of an engineer in the eyes of their peers, which is something Dakota always mentioned struggling with: *"More [contributing to my own recognition] is that I'm gonna have capstones [senior design courses]. And I talked to some of my animal science friends not knowing they didn't have capstones, they thought that capstones are more of an engineering thing.... that kind of helped me boost my confidence in calling myself an engineer, too."*

Terry, despite extensive prior experience, emphasized the motivational impact of validation from an advisor and peers, which provided reassurance and reinforced identity: *"My advisor thought I did a good job on my grant proposal, and I got the grant. And I guess that was an acknowledgment. I guess I also like when I am able to talk about [research] fluidly and people say: that's really cool."* This code demonstrates that external recognition and validation in the form of positive outcome-based or progress-based feedback boosts engineering identity and reduces feeling of insecurity. This also highlights the importance of peer acceptance and how that can appear and the effects it has on the students' perception of themselves as part of the engineering community.

**Speedbumps**

1. Imposterism fed by perceived disciplinary rigidity

Both participants described engineering as an inflexible and narrowly defined domain that privileges traditional technical competencies and marginalizes those working at the edges of established disciplines. This perceived rigidity shaped how participants evaluated their own legitimacy as engineers and contributed to persistent doubt about whether they "fit" within engineering culture. As an example, Dakota articulated a definition of engineering strongly related to highly technical designers fluent in specialized software tools. Although Dakota had limited exposure to these tools, their perceived absence of deep technical expertise became a benchmark against which they judged their own belongingness in engineering: *"I've had introductory experience with AutoCAD, but not a lot. So, I don't know Creo, SOLIDWORKS, and AutoCAD. That's what I think of when I think of engineering, all that nitty, gritty technical stuff. Yeah, that I don't have experience with. So, I guess that's kind of what sets me back sometimes."* They also consistently expressed feelings of being an outsider within the engineering domain, highlighting a sense of exclusion from peers in traditional engineering programs, describing uncertainty about claiming the title of "engineer" as they are in a hybrid program that will not have engineering on their degree: "I'm *not in the college of Engineering. So, I wasn't taking the classes [my sibling] was. So, I feel like from their perspective, it's like, 'why do you get to have an engineering title? If you didn't put in the work I did?', Which I think a lot of people think like when they look down on someone else who thinks they're an engineer."* This framing reflects a narrow conception of engineering competence centered on specific technical practices, reinforcing Dakota's sense of inadequacy despite engagement in interdisciplinary, application-driven research.

Similarly, Terry's experiences revealed how rigid disciplinary expectations can undermine engineering identity. Terry described how the stress on math-intensive coursework in engineering lead to low competence: *"… while at the same time, the standards with which engineers are evaluated on particularly your ability to read tables and then look at graphs, do* *math precisely. I am not terribly good at math, so that makes me feel like I'm not a I'm not a very good engineer from like a perspective of classes, I don't feel like I'm very good at classes, but I know I'm a good engineer, because I've made lots of engineering projects that have succeeded. Yeah, so and ultimately, isn't that what engineers do in the real world? And I think maybe that's the tension for me is like what people in the industry will say."* This tension highlights a disconnect between participants' understandings of engineering practice and the criteria used to assess competence within formal engineering curricula. While Terry acknowledged that research participation helped them recognize the relevance of some foundational content, they continued to view instructional approaches as ineffective and misaligned with how they learn: *"… this project has also helped me see that some of the classes that I thought were stupid because they were so poorly taught, the content is actually like kind of important. And so, I think I've begun to realize why the engineering curriculum is set up the way that it is. I still think it's ineffective"* These reflections illustrate identity-based impostorism, where participants' confidence and legitimacy as engineers are undermined by perceptions of exclusion and rigid disciplinary definitions. Even when engaging in authentic engineering work, feelings of being an outsider can persist, particularly for students navigating interdisciplinary pathways.

2. Value system misalignment

Terry described a tension between their personal values and the cultural norms associated with traditional engineering, resulting in a deliberate distancing from conventional engineering identity. They expressed discomfort with the stereotypes and cultural baggage often attached to the label "engineer," even while actively engaging in engineering work. Terry further noted that standard engineering definitions fail to recognize alternative ways of thinking about systems and making: *"The ways in which I think about systems are generally not the ways in which engineers think. I do a lot of knitting, and I view that as a type of engineering, and I view the women who invented knitting across the world in different sorts of fiber arts as… skilled engineers using science to make garments. But it is not a type of engineering or science that academia privileges. And I don't really want to be associated with an identity… that devalues the work of women and devalues that sort of deep generational knowledge of garment making."* This dissonance between value systems, inclusive notions of engineering, and mainstream disciplinary norms prompted Terry to distance themselves from the traditional engineering identity. While they maintained engagement in engineering practice, this misalignment also contributed to feelings of isolation from peers and uncertainty about belonging. This example highlights how cultural and ethical misfits can function as significant speedbumps for identity development in interdisciplinary contexts.

3. Lack of academic and professional recognition

Both participants described experiences in which the expectations of industry and traditional professional structures conflicted with their interdisciplinary training, undermining their sense of legitimacy as engineers. Dakota, for example, reflected on the challenges of applying for internships or jobs with engineering titles when her major did not explicitly include "engineering": *"I think one of the reasons why I struggle, seeing myself as an engineer so much is because when I would go out and apply for internships or job positions that had, like engineering specs in their description, or even in the title I would get looked past like looked over, because engineering was not in my major name. So, I think that it made me feel like these guys aren't seeing me as qualified to do an engineering position. So why should I think I'm an engineer?"* They also reflected on how the absence of the word "engineering" in job titles or degree labels affected her perception of legitimacy: "it's *kind of hard to see past like your title…. your job title does not have an engineering label in it. It's kind of hard to see past that."*

Terry echoed this sentiment in across their interviews, framing their identity to be more interdisciplinary as they did not feel represented by engineering: "I *love being interdisciplinary, I love communication, and I love… not being constrained to doing a single thing for a long time, I guess… learning about a certain thing for a long time."* Terry did not feel like engineering can give them that opportunity to be interdisciplinary in the way they want and is pivoting their future path away from engineering.

For both participants, these misalignments between professional standards and interdisciplinary training created uncertainty about belonging, legitimacy, and the value of their engineering identity. These experiences emphasize how structural and cultural expectations in the profession can act as significant barriers to confidence and self-recognition for students in emerging or interdisciplinary engineering domains. Structural barriers can impede engineering identity and increase confusion and anxiety over not belonging to engineering despite the student having all the 'Drivers' helping with their competence.

## Discussion

By organizing our findings into Drivers and Speedbumps, we demonstrate that engineering identity development in interdisciplinary contexts is a dynamic, culturally-mediated process shaped by how engineering is defined, valued, and recognized within educational systems, and that it is not developed in a linear way. Grounded in Godwin's RCI framework and engineering identity theory, the results show that identity is simultaneously reinforced and destabilized through students' interactions with institutional structures and disciplinary norms [23], [28].

RQ1 is answered through the identification of cultural and structural Speedbumps that systematically undermine engineering identity for interdisciplinary undergraduates. Participants described engineering as narrowly defined by rigid disciplinary boundaries, math-intensive coursework, and traditional technical competencies, leading to diminished perceptions of competence and persistent impostor feelings despite meaningful technical engagement. Participants also experienced values and identity misalignment, particularly when motivations centered on sustainability, social impact, or community relevance.

RQ2 is answered by identifying Drivers that mitigated these identity threats and supported engineering identity development. Purpose-driven interest functioned as a stabilizing mechanism, allowing students to anchor engagement in societal impact and sustainability. Relevant experiences, particularly long-term undergraduate research and internships, strengthened perceived competence by providing authentic, interdisciplinary applications of technical knowledge [27], [35]. Critically, the identity-affirming impact of these experiences depended on external recognition and validation [23].

Across both research questions, the findings reveal that Drivers and Speedbumps operate in persistent tension. Even when competence, motivation, and professional success were high, dominant cultural narratives of what "counts" as engineering muted the identity-affirming potential of these Drivers.

From an engineering education perspective, these findings call for systemic shifts in how engineering legitimacy is constructed and communicated. Expanding disciplinary narratives to explicitly value interdisciplinary, application-oriented, and socially situated engineering work can reduce identity erosion for students operating at disciplinary intersections [36], [37]. Advising, curriculum design, and professional development structures must evolve to make interdisciplinary pathways visible, coherent, and credible. Faculty and mentors play a particularly consequential role, as their recognition practices directly shape whether students interpret their experiences as legitimate engineering work [38].

## Conclusion and Future Work

This study extends engineering identity research by highlighting the nuanced experiences of students at the intersection of agricultural, biological, and engineering domains. Early exposure, practical experience, purpose-driven interest, and recognition clearly support identity formation, while disciplinary rigidity, professional misalignment, structural barriers, and identity-based impostorism can undermine it. These findings demonstrate that fostering engineering identity in interdisciplinary contexts requires more than traditional skill-building; it demands recognition of alternative competencies, validation of nontraditional pathways, and alignment between student values and professional expectations.

Future research should extend these findings through larger samples across multiple interdisciplinary programs to identify patterns of identity negotiation and persistence. Longitudinal studies following students from early STEM exposure through entry into professional practice could illuminate how Drivers and Speedbumps evolve over time. Additionally, research should explore interventions that explicitly address identity misalignment, structural barriers, and perceptions of disciplinary rigidity, including mentorship programs, curriculum redesign, and recognition structures that validate nontraditional engineering contributions. Narrative analysis may also be particularly valuable for capturing the nuanced “how” behind the challenges students face, providing insight into the strategies they employ to navigate identity tensions and structural obstacles.

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