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Bridging Cognitive Neuroscience and Engineering Education: Fostering Value and Identity Awareness in Engineering Students

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1. Introduction

This evidence-based work-in-progress paper examines engineering undergraduate students' perceptions of engineering values. Many students enter engineering programs with personal values such as creativity, empathy, and a desire to contribute to society, yet come to perceive that success in engineering is defined by narrower standards emphasizing technical competence and intelligence [1]. As students progress through their programs, this mismatch between personal values and perceived societal norms in being an engineer can create value misalignment, leading to identity-related tension as students question whether they belong in engineering or whether their ways of thinking and contributing are valued. Over time, students may feel pressure to suppress aspects of their identity to be seen as legitimate or successful. Yet, engineering curricula rarely provide explicit tools or structured opportunities to help students make sense of these experiences as part of their professional development.

Concepts from cognitive neuroscience, for example, neuroplasticity, defined as the brain's capacity to change its structure and function in response to experience and learning, and metacognition, defined as the ability to monitor, evaluate, and regulate one's own cognitive processes, including thinking, learning, and problem-solving, provide a way for students to understand how their brain learns and their thinking develops, and to reflect upon their personal identities in engineering. Introducing such cognitive neuroscience principles may thus provide students with concrete tools and language for understanding their capacity to grow, supporting both their learning and the development of a more resilient, inclusive engineering identity.

Faulkner [2] describes a "technicist" characterization of engineering that prioritizes technical mastery over socially oriented skills. Interviews with engineering students by Liquete, Dekoninck, and Wisker [1] similarly reveal a tension between students' own views of engineers as creative and collaborative and the narrow, often gendered stereotypes they perceive as dominant in the field. Such messaging risks excluding students whose identities do not align with these norms. This is consequential as students who perceive engineering as consistent with their personal identity are more likely to persist in the field [4]. As engineering identity is often shaped implicitly through evaluation practices and classroom norms rather than explicit discussion, students remain vulnerable to persistent, narrow definitions of engineering success. Thus, it is vital to adopt educational approaches that intentionally provide students with tools, language, and structured opportunities to develop inclusive and resilient engineering identities.

Thus, in this study, we aim to better understand students' perceptions of what traits society values in engineers, and how these relate to their own identities and values. This will better inform our approach to nurturing students' sense of belonging within engineering programs and preparing students for careers in engineering. In particular, developing interventions informed by insights from cognitive neuroscience paired with guided reflection on their engineering identity can provide students with tools to enable students to reflect on their learning, development, and sense of belonging. The study is guided by the following research questions:

1. How does the alignment between students' personal values and perceived societal values in the engineering field impact their mental well-being, sense of belonging, and academic resilience?
2. What are engineering students' exposure to neuroscience principles, and how do students apply cognitive neuroscience to their learning and development?
3. Can targeted interventions incorporating neuroscience principles improve students' mental well-being, sense of belonging, and academic resilience?

In this study, we define value misalignment as the perceived difference between the traits that students personally value in engineers and the traits they believe society values in engineers. Identity-related tension is used to describe the cognitive and emotional effort involved in reconciling these perceptions with one's developing sense of self as an engineer. A student's sense of belonging is understood as the extent to which they feel accepted, valued, and able to participate authentically within engineering learning environments.

2. Methods

2.1. Phase 1: preliminary survey & motivating evidence

A pilot survey was administered in Spring 2025 to undergraduate mechanical engineering students at a Hispanic-Serving Institution in California's Central Valley. Participation was voluntary and did not affect course grades. A total of N = 36 students participated, and N = 20 completed the survey. Participants could skip questions. As a result, incomplete measurement scores were excluded, but open-ended responses were still included because they were valuable.

The online survey was distributed via email during the final weeks of the semester and required approximately 20 minutes to complete. The survey included validated measures of happiness and well-being (PERMA-Profiler) [5], academic self-efficacy (CASES) [6], general self-efficacy (NGSE) [7], and Academic Resilience Scale (ARS-30) [8]. Open-ended questions asked students to list traits they personally valued in engineers and traits they believed society values in engineers. These responses were used to examine students' identity alignment with societal perception of engineers. Descriptive statistics and thematic analysis were used to analyze quantitative and qualitative responses, respectively. The pilot was designed to assess feasibility and establish preliminary data to guide the intervention in the main study.

We hypothesize that identity-related tension experienced over time in engineering programs may affect students' self-efficacy and well-being. To examine this, we collected data on PERMA, CASES, and ARS-30, along with students' perceptions of personal values and societal values attributed to engineers. Students were grouped based on the presence of value differences, and misalignment was quantified by counting the number of value categories that did not match. We then examined relationships between value misalignment and PERMA and NGSE scores to explore whether students' identity-related tension affects their measures of mental health well-being and self-efficacy and establish baseline relationships in the absence of an intervention.

2.2. Intervention design: cognitive neuroscience-informed reflection module

We propose a structured, low-burden, in-class intervention designed to support early engineering students' identity development, sense of belonging, and mental well-being. Students are introduced to selected concepts from cognitive neuroscience and how these concepts relate to learning and identity formation in engineering. Students then engage in brief, guided activities that prompt them to apply these concepts to their own academic experiences. These activities are designed to help reduce identity-related tension by providing students with tools to reflect on value misalignment and to recognize the multifaceted nature of engineering, including skills and traits beyond technical competence [2].

Examples of core concepts bridging cognitive neuroscience and evidence-based pedagogy that can be used for the interventions include neuroplasticity and metacognition. In this context, neuroplasticity frames ability, identity, and definitions of success as changing through experience rather than fixed traits. This framing helps legitimize multiple ways of being an engineer and reinforces the idea that students can develop their engineering identity and self-efficacy over time. For example, students engage in a brief reflection activity focused on error-driven learning, where they describe moments of difficulty, what changed through practice or feedback, and which strategies reshaped their understanding. The activity emphasizes process and change rather than personal deficiency, reframing struggle as evidence of learning and supporting shared vulnerability and collective resilience.

Metacognitive strategies further provide students with tools to reflect on how societal norms are learned and internalized within engineering. These processes are rarely made explicit and transparently developed in classrooms. The intervention intentionally scaffolds reflection on how students explain performance differences in the field. For example, students are presented with brief scenarios describing peers with different performance patterns and reflect on the explanations they assign to these differences through guided prompts. This activity makes explicit how these interpretations shape judgments about competence and belonging are cognitively constructed, rather than objectively determined, and supports students in navigating value misalignment without requiring conformity to narrow definitions of engineering success.

Together, these structured activities support students' understanding of how learning involves cognitive processes. Drawing on cognitive neuroscience-informed perspectives through guided self-reflection, students are encouraged to recognize the patterns in how they think, feel, interpret experiences, and respond to challenges without judging or changing who they are. To evaluate potential changes associated with these activities, pre- and post-surveys will be administered, including a validated Sense of Belonging measure to assess students' perceived belonging within engineering.

3. Preliminary Results

Students' responses were coded into three main categories: technical skills, effort, and soft skills (see Appendix Table 1 for coding details). Students most often listed technical skills as societally valued traits in engineers, such as technical mastery and intelligence, while they personally emphasized effort and soft skills, including empathy and creativity (Figure 1). In open-ended responses, students described a mismatch between what they value and what they perceive to be rewarded in engineering, with some reporting a reduced sense of belonging. Upper-division students, who had more exposure to engineering culture in practice, reported greater pressure to conform to narrow definitions of engineering success, suggesting that identity-related tension increases over time. Several students noted frustration that personally valued qualities, such as creativity and interpersonal skills, were not recognized or rewarded within engineering culture.

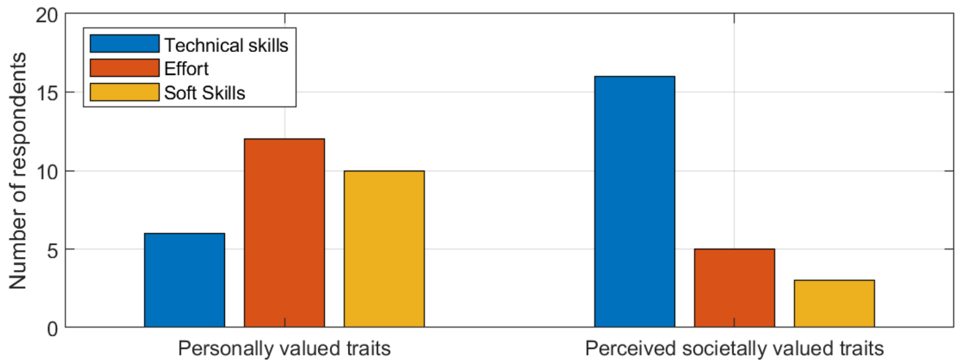

Figure 1: Comparison of students' personally valued traits and perceived societally valued traits in engineers.

For example, these patterns are illustrated by one upper-division student who described valuing "the ability to carry on a conversation and be wholesome as a person, almost like a person who is enjoyable to be around." However, when asked what traits they believed society values in engineers, the same student responded, "…someone who is only smart." This contrast highlights a perceived disconnect between personal values and societal definitions of engineering success, suggesting identity-related tension that may relate to students' self-efficacy and well-being. Students with value misalignment tended to report slightly lower self-efficacy (NGSE = 3.6 vs. 4.1) and slightly lower overall well-being (overall well-being in PERMA= 5.3 vs. 5.6). The trends were modest given the small sample size.

4. Conclusions

This work-in-progress study highlights how engineering students may experience identity-related tension when their personal values do not align with perceived norms of success in the field. The preliminary findings suggest that students benefit from explicit tools and opportunities to practice understanding and reflecting on their learning and identity. By introducing two core neuroscience concepts through structured classroom activities, this work proposes a pathway to help students navigate value misalignment while supporting engagement and learning. Ultimately, this approach aims to equip students with transferable tools that extend beyond the classroom to support professional development and long-term mental well-being. Future phases of this work will implement and evaluate the proposed neuroscience-informed intervention to examine its effects on students' sense of belonging, self-efficacy, and well-being over time.

5. References

[1] E. Liquete, E. Dekoninck, and G. Wisker, “From student to engineer: identity formation in engineering education,” European Journal of Engineering Education, pp. 1–24, Jul. 2025, doi: 10.1080/03043797.2025.2537694.

[2] W. Faulkner, “`Nuts and Bolts and people’,” Social Studies of Science, vol. 37, no. 3, pp. 331–356, May 2007, doi: 10.1177/0306312706072175.

[3] B. E. Hughes et al., “Entering the community of practice: changes in engineering students’ engineering identities and perceptions of the field,” European Journal of Engineering Education, vol. 46, no. 6, pp. 968–986, Jul. 2021, doi: 10.1080/03043797.2021.1947197.

[4] H. M. Matusovich, R. A. Streveler, and R. L. Miller, “Why do students choose engineering? A qualitative, longitudinal investigation of students’ motivational values,” Journal of Engineering Education, vol. 99, no. 4, pp. 289–303, Oct. 2010, doi: 10.1002/j.2168-9830.2010.tb01064.x.

[5] J. Butler and M. L. Kern, “The PERMA-Profiler: A brief multidimensional measure of flourishing,” International Journal of Wellbeing, vol. 6, no. 3, pp. 1–48, 2016, doi: 10.5502/ijw.v6i3.526.

[6] S. V. Owen and R. D. Froman, “Development of a college academic self-efficacy scale,” ERIC, Institute of Education Sciences, ERIC No. ED298158, Apr. 1988.

[7] G. Chen, S. M. Gully, and D. Eden, “New General Self-Efficacy Scale (NGSE),” APA PsycTests, 2001, doi: 10.1037/t08800-000.

[8] S. Cassidy, “The Academic Resilience Scale (ARS-30): A New Multidimensional Construct Measure,” *Frontiers in Psychology*, vol. 7, p. 1787, 2016, doi: 10.3389/fpsyg.2016.01787.

6. Appendices

Table 1. Primary coded categories derived from students’ responses regarding personally valued traits and traits perceived as societally valued in engineers.

Group	Trait Code Category	Student responses
1 - Technical skills	Technical skill	Coding, Design, Analysis, Logical thinking, Problem-solving
	Intelligence	Being smart, Naturally gifted
	Perfection	Accuracy, Being flawless, Not making mistakes, Being careful (attention to detail), Precision
2 - Effort	Resilience/work ethic	Perseverance (continue effort despite obstacles), Persistence, Hardworking,

		Sustained effort, Patience, Emotional strength, Coping with stress, Self-reflection, Being determined
	dedication	Being determined, Being passionate about engineering,
3 - Soft skills	Communication/Interpersonal	Teamwork, Expressing ideas, Collaboration
	Creativity	Innovation, Thinking outside the box, Ingenious
	Ethics/Social impact	Helping others, Being responsible, Kindness, Related to empathy, Being considerate, Humility
	planning/metacognition	Knowing how long it will take to complete something, Self-reflection

Table 2. CASES scores by demographic group, reported as mean and standard deviation.

Group	CASES (Average)	CASES (STDEV)
Total (only fully completed response)	2.7	0.62
Total (overall)	2.7	0.58
Female (N = 3)	3.1	0.37
Male (N=17)	2.7	0.63
Gender - Unknown/Decline to state/non-binary (N = 8)	2.73	0.48
White or Caucasian only (N = 17)	2.55	0.69
Black or African American, Asian, and/or Other (N = 9)	2.95	0.42
Latino/Hispanic Origin (N = 8)	2.90	0.41
Low to Low-middle (N = 11)	2.9	0.6
Middle to Upper (N= 8)	2.37	0.38

Non-First generation college (N = 13)	2.53	0.58
First generation college (N = 7)	3.03	0.55
First generation college - Unknown (N = 8)	2.77	0.47

Table 3. Factor Overall well-being in PERMA scores by demographic group, reported as mean and standard deviation.

Group	PERMA - Overall well-being (Average)	PERMA - Overall well-being (STDEV)
Total (overall)	4.96	0.74
Female (N = 3)	4.60	0.69
Male (N = 17)	4.93	0.73
Gender - Unknown/Decline to state/non-binary (N = 11)	5.12	0.72
White or Caucasian only (N = 12)	4.92	0.72
Black or African American, Asian, and/or Other (N = 8)	4.84	0.81
Hispanic Origin (N = 8)	4.45	0.80
Low to Low-Middle income (N = 11)	4.85	0.71
Middle to Upper (N = 8)	4.94	0.88
Non-First generation (N = 13)	5.01	0.78
First generation (N = 7)	4.79	0.73
First generation - Unknown (N = 11)	5.03	0.66

Table 4. ARS-30 scores by demographic group, reported as mean and standard deviation.

Group	ARS-30 Score (Average)	Score (stdev)
Total (overall)	106.32	16.55
Female (N=3)	106.33	20.50
Male (N = 17)	107.35	17.97
Gender - Unknown/Decline to state/non-binary (N = 5)	101.00	7.40
White or Caucasian only (N = 11)	106.75	20.13
Black or African American, Asian, and/or Other (N = 9)	109.78	13.84
Hispanic Origin	107.25	18.94
Low to Low-Middle income (N = 11)	103.18	20.02
Middle to Upper (N = 8)	110.63	13.02
Non-First generation (N = 13)	112.50	14.82
First generation (N = 7)	94.43	15.20
First generation - Unknown (N = 11)	122.00	105.25

Table 5. Comparison of Traits Students Personally Value in Engineers and Traits They Believe Society Values, by Academic Level

Student	Traits they personally value in engineers	Traits they think society values in engineers
Freshman	"Careful and Hardworking"	"Smart and Hardworking"
Freshman	"Smart"	"Smart"
Freshman	"I value openness to ideas, inclusivity, problem solving, intelligence, motivation, not giving up, challenging oneself, collaboration, skill, ability to teach/explain concepts to others	"Primarily Skill, Problem-solving Ability, and Confidence. Society as a whole also tends to value Male engineers above Female or gender-diverse engineers, despite gender have

	who may not have the same experience/background knowledge.”	no impact on skill or ability or knowledge.”
Sophomore	“Perseverance I guess?”	“Not sure, maybe Capability”
Junior	“The ability to carry on a conversation and be wholesome as a person, almost like a person who is enjoyable to be around, inside and outside the classroom setting.”	“The traits they value in an engineer would be their computational and number crunching skills, as the title categorizes them as almost a "human calculator" or someone who is only smar.t”
Junior	“I just want to learn about cars and how I can improve them make them using less components.”	“They value it for you to follow the system.”
Junior	“camaraderie”	“Self-reliance and obedience”
Senior	“Someone who’s creative and willing to think outside the box and knows how to effectively communicate ideas.”	“Someone who just knows SolidWorks.”