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Results from Understanding Interactions Between Affect and Identity in First- and Second-Year Engineering Students (PFE:RIEF)

Dr. Jessica Swenson, University at Buffalo, The State University of New York

Jessica Swenson is an Assistant Professor at the University at Buffalo. She was awarded her doctorate and masters from Tufts University in mechanical engineering and STEM education respectively, and completed postdoctoral work at the University of Michigan. Her research examines emotions within engineering problem solving and the student experience, engineering judgment, and elementary school teachers learning to teach engineering.

Dr. Emma Treadway, Trinity University

Emma Treadway received the B.S. degree in Engineering Science from Trinity University in 2011, and her M.S.E. and Ph.D. degrees in Mechanical Engineering from the University of Michigan, Ann Arbor in 2017 and 2019, respectively. She is an Assistant Professor in the Department of Engineering Science at Trinity University in San Antonio, Texas. Her research interests include haptics and the role of affect in engineering education.

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Introduction

The development of students' engineering identity has long been linked to retention within engineering programs, particularly during their first two years of engineering coursework. Measurements of engineering identity typically measure changes over lengthy periods of time. Our project is interested in investigating how students' day-to-day experience, especially problem solving experiences, contribute to or detract from the development of engineering identity. We use affect, or emotions, feelings, beliefs, values, and moods, to examine these day-to-day experiences. During problem solving activities, students may experience an affective pathway, or sequence of shorter momentary emotions (local affect). Positive or negative affective pathways can accumulate to influence a student's global affect, or their overall stable and longer-lasting attitudes or beliefs about a particular subject.

Our project (NSF award number 2204726) examines how affective experiences interact with or influence the development of engineering identity. For this project, we examine the subjects of engineering, mathematics, and science, as these courses are all important in engineering students' experiences in the first two years of coursework. Our three project questions are:

RQ1: How are 1st and 2nd year engineering students' local affect different or the same while doing engineering work vs. mathematics and science work?

RQ2: Over the course of their early college experiences with mathematics, science, and engineering, how do students' global affect about mathematics, science, and engineering change?

RQ3: How do students' local and global affect about mathematics, science, and engineering contribute to/interact with their identities, including engineering identity?

Background

This project examines the overlap between two theoretical frameworks, engineering identity and affect. For this study, we use the model of engineering identity used by Godwin [1] that is built upon prior studies in science education by Hazari [2] and Carlone and Johnson [3]. Engineering identity is conceptualized as consisting of performance, competence, interest, and recognition [4].

The second framework is affect, or emotions, feelings, as well as the non-cognitive components of disciplinary beliefs, values, and self-concepts [5], [6]. Over the course of our research, the most common affect experienced by engineering students during problem-solving or other course-based experiences include confusion, frustration, satisfaction, accomplishment, and pride. Affect in a more stable, longer lasting form is global affect. Meta-affect, a student's cognition or affect about their own affect [5], [7], [8], [9], can influence the impacts of an affective state on a student. Meta-affect consists of everything from simple awareness of an emotion or feeling to regulation of that emotion, or even embracing it as evidence that learning is taking place [5], [9].

Methods

This is a longitudinal mixed-methods study following two cohorts of engineering science students, originally intending to follow them as they progressed through the first two years of their engineering degrees. Supplemental support and a no-cost extension have allowed us to continue with data collection past the originally-intended two years, enabling additional interviews and a member-checking reflection. The protocol was approved by the Trinity University Institutional Review Board. The primary data collection for this study is retrospective interviews with participants at the end of each semester they are studying engineering. We have collected 90 end of semester interviews between cohorts 1 and 2 that are listed in Tables 1 and 2 below.

Table I. Data Collected for Cohort 1

Pseudonym	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5	Additional Interviews	Reflection
Noelle	x	x	x	x	x	Senior Interview	
Bob	x	x	x	x	x	Senior Interview	x
Projector Man	x	x	x	x	x	Senior Interview	x
Nicole	x	x	x	x	x		x
Hope	x	x	x	x	x	Senior Interview	
Ozarka	x	x	x	x	x	Senior Interview	x
Dante	x	x	x	x	x	Senior Interview	x
Max	x	x	x	x			
Anne	x	x					x
Snowman	x			x			
Buzz	x						
Valeria Row	x						
Skye	x	x	Left Engineering				
Ella Mayo	x	x	Left Engineering			Exit Interview	
Emily	x	x	Left Engineering				x
CJ	x	x	Left Engineering				x
Taine	x	Left Engineering					

Table 2. Data Collected for Cohort 2

Pseudonym	Interview 1	Interview 2	Interview 3	Interview 4	Reflection
Ted Allen	x	x	x	Exit Interview	
Alex	x	x	x	x	
Valentino Ortega	x	x	x	x	
Link	x	x		x	x
Mckenzie	x	x		x	
Snoopy	x		x	x	
Your Highness	x		x	x	x
Nugget	x			x	x
Sither	x		Transferred Institutions		
Olaf	x	x	Left Engineering		x

Survey Participation

Interview participants as well as additional classmates who consented to participate in this study completed surveys at the end of each semester. The survey included the engineering identity instrument developed by Godwin [1] and Liekert-style questions about global affect (My feelings about [subject] are generally positive) as well as an instrument for measuring local affect that we have been developing [10], [11].

Table 3. Survey data collected from both cohorts.

	Semester 1	Semester 2	Semester 3	Semester 4
Cohort 1	20	19	9	9
Cohort 2	12	13	5	5

In order to achieve a higher *n* for our affective pathways survey instrument, we also distributed it to a second group of students as part of an end-of-semester survey at a second institution for students who had completed an open-ended modeling project in their Statics class, using a protocol approved by the University at Buffalo Institutional Review Board. Over the course of the Fall 2023 and Spring 2024 semesters, 180 students responded to the survey, with 161 completing the affective pathways survey question. Along with the affective pathways instrument, the survey also included Godwin's engineering identity instrument [1], Liekert-scale questions about students' confidence in achieving course-specific learning objectives, and several other open-ended and Liekert-style questions about the modeling problem.

Data Analysis

Interviews were transcribed, either by AI or a professional human transcriber. A member of our research team (often an undergraduate researcher) coded transcripts with the assistance of a worksheet that provides definitions from our theoretical framework. As they code, they annotate the transcript with specific highlights, text colors, or text in italics for each conceptual element (local affect, engineering identity, etc.). The undergraduate coder then fills out the worksheet by pasting in utterances or counting affective words or phrases. Initially, members of the research

team each independently code one transcript and compare and discuss their results. Discrepancies are brought to the research team. This process continues until the new coder or pair of coders can reliably produce the same codes as others on the team, after which they can code independently but still bring any utterances they are unsure about to the team for discussion. The annotated transcripts allow for another member of the research team to quickly scan the transcript and see the coding, which other members review when utilizing data for a manuscript.

Survey results from the affective pathways instrument were analyzed using social network analyses. Additional correlation analyses were performed to explore correlations between students' emotions and their engineering identity and course-specific confidence.

Summary of Project Results

The following provides a brief overview of project results due to the limited space of this paper.

Results from Qualitative Analysis of Interviews

In our analysis of the effects of local affect on engineering identity [4], we found an influence of local affect on identity in the forms of interest, performance, and competence but not recognition (Fig. 1). Positive local affect increased students' interest and built performance and competence; we found that meta-affect is an important mediator for negative local affect in how it influences performance and competence. In other work, we have found that open-ended modeling problems provide opportunities for some students to strengthen their engineering identities [12] and that students' local affect can work to strengthen or change beliefs that influence engineering identity [13]. In some cases, identities outside of engineering also strengthen or weaken students' engineering identities [14], [15]. Supporting evidence can be found in [4].

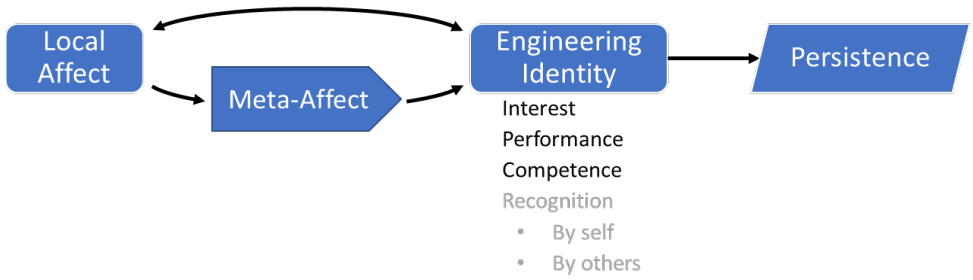

Figure 1: Interactions between local affect and engineering identity (reproduced from [4]).

Survey results

We have previously reported on validity evidence gathered about the affective pathways survey instrument [10]. Results from our analysis of the survey distributed at a second institution echo qualitative results in supporting the existence of interactions between local affect and engineering identity, in the context of affective pathways experienced while completing an open-ended modeling project in a Statics course. Details of these analyses and results are currently under review for publication, so we summarize here a few key conclusions only. First, we found that positive emotions throughout students' affective pathways correlated positively with engineering interest. As we examined students' affective pathways, confusion and accomplishment emerged as key emotions in the social network analyses, with a high centrality

score indicating that students' affective pathways can proceed in many directions from these emotions; confusion also had important correlations with identity, with students who reported confusion at any point reporting lower performance/competence that those who did not (104 students employing confusion had a mean performance/competence score of 5.53 while 50 who did not employ confusion had a mean score of 5.83, $p = 0.04, t(152)=-2.069$).

Broader Impacts and Dissemination

To disseminate these results to instructors, we have held workshops at the University of Michigan and the 2024 Frontiers in Education Conference as well as a special session at ASEE 2025. This project has provided opportunities for 10 undergraduate students and one graduate student to perform research in the field of engineering education; many of these students are co-authors on our publications [4], [10], [12], [13], [14], [15], [16], [17], [18].

Conclusions and Future Work

The results from this project have filled a gap between two areas of literature: emotions and engineering identity. The results have highlighted the importance of meta-affect in how students' emotions influence their engineering identities. This project has also resulted in methodological innovations that will aid other researchers, including a survey instrument for measuring local affect and methods for participatory reflection.

We hope to continue our explorations of interactions between local affect and engineering identity, and global affect and engineering identity. At this time, we have only examined how local affect influences identity and believe there is more to discover. Additionally, a significant portion of our results point to the importance of meta-affect as a mediator or mitigator for negative affective experiences. While previous studies agree with the importance of meta-affect for regulation, little work has explored how reframing difficult experiences as productive for learning or disciplinary authentic develops over time.

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