Research Initiation: Understanding Interactions Between Affect and Identity in First- and Second-Year Engineering Students

Abstract
This paper provides an update on our progress within our National Science Foundation project examining the first two years of undergraduate engineering students' experiences through self-reports of their affect and engineering identity.

Keywords: identity, affect, emotion, undergraduate engineering

Introduction

Students' development of their engineering identity is known to play an important role in their decision to persist within the major [1], [2]. The first two years of students' experiences are particularly critical, as most students who persist beyond this point will likely continue on to receive an engineering degree. While identity has been explored from many different perspectives, the influence of students' affect on identity development has not been addressed. Existing models of affect and engineering identity suggest that local affect (the changing emotions that students experience during disciplinary activity) and global affect (the broad attitudes, values, and beliefs that students hold about a discipline) have potential to influence and interact with engineering identity (performance/competence, interest, and recognition) [2], [3], and in turn, to influence retention. Our study investigates this potential interaction through examining the experiences of engineering students as they progress through their first and second years of an engineering program.

Our study aims to answer the following research questions:

1) How are 1st and 2nd year engineering students' local affect different or the same while doing engineering work vs. mathematics and science work?
2) Over the course of their early college experiences with mathematics, science, and engineering, how do students' global affect about mathematics, science, and engineering change?
3) How do students' local and global affect about mathematics, science, and engineering contribute to/interact with their identities, including engineering identity?

While affect has been widely studied using qualitative methods, our parallel use of qualitative interviews and piloting of quantitative survey instruments will contribute to the development of quantitative measures of affect that can be employed by others in STEM education. For the purposes of this short grant summary, we will be focusing on the second research question. In addition, we will examine semester-to-semester data examining students' engineering identity development, related to the third research question.

Background

Our research investigates the connections between theories of affect and models of engineering identity. We began our work grounded in prior theories of affect [4] and engineering identity [2], seeking to find connections in early engineering students (Figure 1).

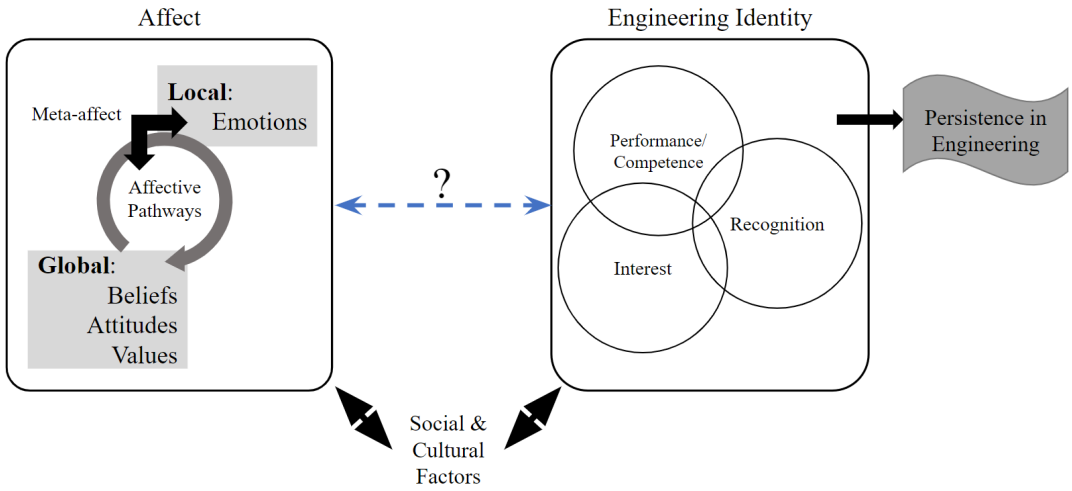

Figure 1: This work seeks to connect affect (DeBellis and Goldin [4]) and identity (Godwin [2]) frameworks to understand the implications of affect on engineering students.

Despite the stereotype of engineering as purely rational [5], emotions and other affective constructs have been found to be an important part of engineering students' experiences [6], [7], [8], [9]. Affect is a term encompassing not only students' emotions, but also their moods, attitudes, beliefs, and values related to a discipline [4], [9]. We draw on the model of affect proposed by DeBellis and Goldin in mathematics education [4], which posits that local affect (the in-the-moment emotions experienced by a student performing disciplinary activities like problem-solving) falls into typical cycles for similar types of problems, forming affective pathways (the sequences of emotions that students experience). Local affect interacts with global affect (the more stable beliefs, attitudes, and values a student holds towards a discipline) through repeated tracing of these pathways, with positive or negative pathways respectively holding the power to make attitudes towards a discipline more positive or more negative over time. The relationship between local and global affect is mitigated by meta-affect, which consists of the monitoring of/cognition about affect or students' affect about their own affect; this also includes competencies such as affective regulation. As much of engineering students' early required coursework takes place in mathematics and science departments, it is important to explore students' affective experiences not only in their engineering classes but also in mathematics and science. Our study examines how each of these influences the development of a student's engineering identity.

While a number of models of identity have been considered within the field of engineering [1], Godwin's [2] model that consists of recognition, interest, and performance/competence has become the most commonly used. Her model is derived from previous studies by Hazari [3] and Carlone & Johnson [10]. In our study, we have considered the definitions of recognition, interest, performance, and competence from all three studies, in order to draw from both qualitative and quantitative work on the topic. Utilizing and considering all definitions has afforded our research team to include constructs such as self-recognition [10] and belief in ability [3]. Prior work has indicated that performance and competence alone are not sufficient for establishing a strong identity unless paired with interest and recognition and that recognition is the most important part of identity development [11].

Methods

This study takes place at a small, private liberal arts university in the Southwest United States that has strong STEM programs. Students do not declare their major until the end of sophomore year, yet engineering design coursework typically begins during the first semester of study. From this first engineering course, we recruited students for our study, following a protocol approved by the university's Institutional Review Board. Once students consented to participate, they filled out a pre-study survey with demographic information that we used to select a diverse set of students by gender, race, and other identity factors such as athlete and musician; this pre-survey also included survey questions about global affect towards math, science, and engineering. Students were also asked to pick a pseudonym for the authors to store their data and write about them in publications. During each of the two years that we invited students to participate, 29 students consented to participate in either surveys or surveys and interviews; in each cohort, one student who consented did not continue on to complete the demographic information. The goal was to recruit two groups of 16 for the interview cohorts; in the end, the year 1 interview cohort consisted of 17 students and the year 2 interview cohort consisted of 11 students (all students who consented to interviews were invited to participate in year 2, but only 11 responded or were still interested). Not every student who consented to participate and not every student who was asked to participate responded to our e-mails requesting participation in interviews. The interview protocol includes questions about students' global affect, identity, and local affect during engineering, math, and science activities during the semester. Between Year 1 and Year 2 of the grant, revisions were made to our interview protocol to better capture data on affect and identity we are aiming for.

Students who consented to participate were all invited to participate in a semi-anonymous survey at the end of each semester that they were still pursuing engineering coursework. The survey includes questions about students about their feelings/attitudes towards math, science, and engineering (global affect), the identity questions developed by Hazari [3] and modified for engineering by Godwin [2], and to describe the sequence of emotions that they experienced while solving a challenging problem in their math, science and engineering classes that semester

(affective pathways) [12], [13]. To each of the items in Godwin's survey instrument and the three global affect questions we developed, participants were asked to rate each statement on a seven point Liekert scale how much they agree with the presented statement. For the affective pathway questions, students were asked to drag and drop in order the typical feelings they had while solving a difficult problem in each of their math, science, and engineering courses.

To enable us to track participants across each of the surveys and connect them back to their pseudonyms given in the consent form, each survey and the pre-study demographic questionnaire all included a "secret identifier" composed of the year the student started college, the last letter of their middle name, the last two digits of their telephone number, and the month their birthday falls in. Students would occasionally make mistakes in entering this data (e.g., entering their expected graduation year rather than their start year or a different letter in the middle name field), but as long as three of the four fields matched we assumed that the responses came from the same participant.

Data Collection

As detailed in our methods, it was important to us to select a diverse cohort from the students that consented to participate in the interviews. Table 1 details the gender identities of students who consented and those who were selected to participate in the interviews. Students were given the option to select as many racial/ethnic identifiers as desired, so these numbers total higher than the number of participants: for Cohort 1, 23 students selected White, 5 selected Hispanic, 3 selected Multiracial, 2 selected Asian, and 2 selected Latinx/o/é/a, and 1 did not reply. In Cohort 2, 22 selected White, 6 selected Hispanic, 4 selected Asian, 1 selected Black or African American, 3 selected Latinx/o/é/a, 2 selected multiracial, and 1 did not reply. There is a significant difference between the consenting populations from year one to year two, reflecting the inconsistency in demographics from year-to-year of a small engineering program.

Table 1: Consented Participants' Gender Identities

Gender Identity (per pre-survey)	Cohort 1 (total consented)	Cohort 1 (interviews)	Cohort 2 (total consented)	Cohort 2 (interviews)
Male	9	7	20	6
Female	18	9	8	4
Nonbinary	1	1	0	0
No response	1	0	1	0

Table 2 details the data collected across the duration of our grant thus far. As expected, our cohorts reduce in size as we progress through the study, either because students stopped pursuing an engineering degree or did not respond to our requests for interviews or survey completion.

Where students completed only a portion of the survey, we have included whatever responses were recorded in our data analysis.

Table 2: Data Collected

	Semester 1	Semester 2	Semester 3
Interviews, Cohort 1	17	13 (plus 1 exit interview)	7
Survey Responses, Cohort 1	20	19	9
Interviews, Cohort 2	–	–	10
Survey Responses, Cohort 2	–	–	11 (only 8 complete)

Results

In this section, we present some of the results from our study, focusing primarily on the survey responses related to global affect and engineering identity. In previous work, we presented on our development of a survey instrument for measuring local affect [12], [13] that is also included in these same end-of-semester surveys. In other papers simultaneously submitted to this conference, we explore two aspects of the interviews to analyze connections between students' meta-affect and their identities and to examine the importance of the Makerspace in building engineering identity for some students [14], [15]. The results presented below are from the survey data collected during the first year and a half of our study. These results help us answer 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? In addition, we examine the changes in students' engineering identity, making some inroads towards addressing RQ3 by connecting engineering identity with global affect.

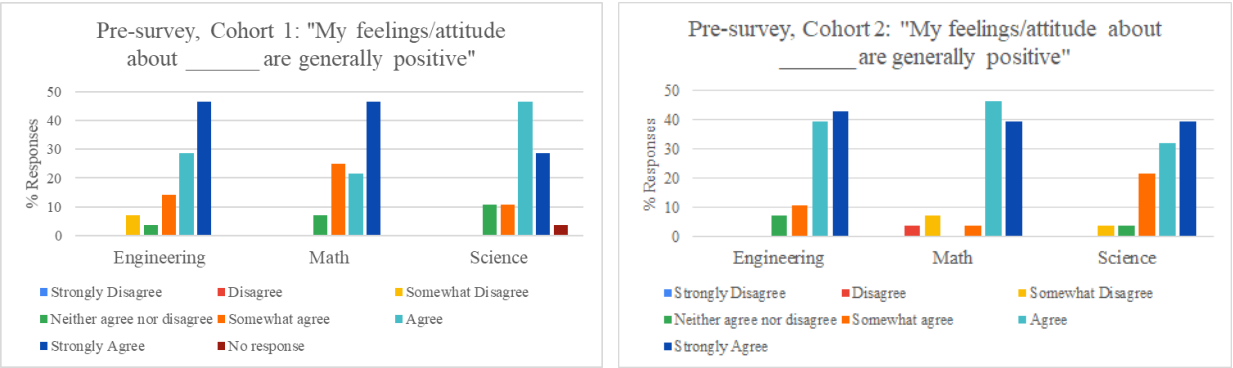

Figure 2: Pre-survey global attitudes towards engineering and related disciplines for the two cohorts (each n=28).

The results shown in Figure 2 represent the global affect of the 28 participants in each cohort who completed the pre-survey that was given at the time of consent. At this time, students are

enrolled in their first engineering coursework at the study site. Students both in cohorts have generally positive feelings about math, science, and engineering at this point in time. These feelings and attitudes are necessarily shaped largely by their experiences in high school or earlier. From the interview data, we know not all students have experience with engineering prior to entering the program. In the interviews, students also break down their feelings towards science by subject, with many students expressing a preference for physics or chemistry over biology.

For the remainder of the results, we will focus on Cohort 1 as we have the most data about their engineering experiences and identity development as they move through their coursework.

Identity Progression: Cohort 1

At the end of their first semester, there was a distribution of responses to the questions in the identity instrument (Fig. 3), but the majority of responses skewed positive, with more respondents replying in the affirmative to some degree (slightly agree, agree, or strongly agree) to all items than neutral or negative.

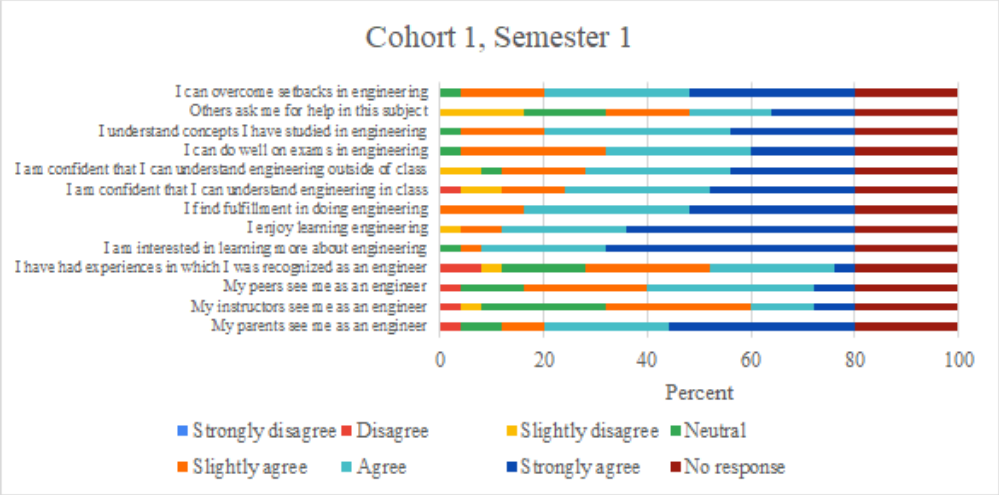

Figure 3: Responses to the identity portion of the survey at the end of the first semester for Cohort 1 (Percent is of the n = 25 students who have completed at least one end-of-semester survey during the study duration).

Identity results from the second survey are shown in Fig. 4 below; students who had left engineering coursework to pursue another major after the first semester were no longer eligible to participate in the survey, and are indicated in brown below. By the end of the second semester, responses to the identity instrument had become more negative among our respondents: two participants who subsequently stopped pursuing engineering coursework during the next semester chose “strongly disagree” or “disagree” to most of the items in the instrument, and even among the participants who chose to continue in engineering, fewer responded “strongly agree” to the questions.

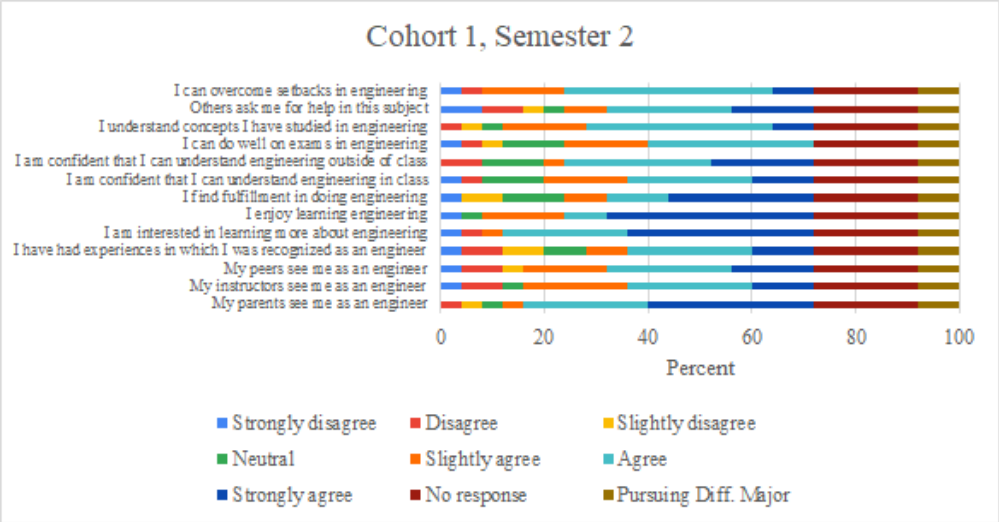

Figure 4: Responses to the identity portion of the survey at the end of the second semester for Cohort 1 (Percent is of the n = 25 students who have completed at least one end-of-semester survey during the study duration).

Responses from the third semester are shown in Figure 5. Between semesters 2 and 3, we saw a major drop-off in survey completion, due in part to some participants switching majors (four of the participants who had completed the survey at the end of the second semester switched out of engineering after that point) but also due to more participants who were still pursuing engineering electing not to respond.

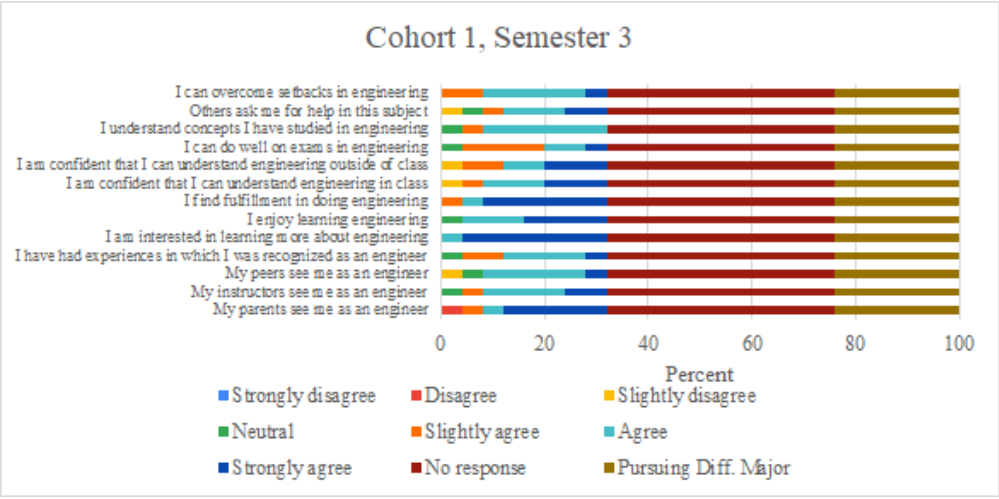

Figure 5: Responses to the identity portion of the survey at the end of the third semester for Cohort 1 (Percent is of the n = 25 students who have completed at least one end-of-semester survey during the study duration).

Affect Progression: Cohort 1

Participants responded to questions about their global affect in math, science, and engineering both in the pre-survey (Fig. 2) and in each post-semester survey (Fig. 6). Trends mirror those in engineering identity, with attitudes becoming more negative at the end of semester 2 before turning quite positive (especially global affect towards engineering) in the semester 3 survey. We believe this turn is due to students who had negative feelings towards engineering leaving engineering.

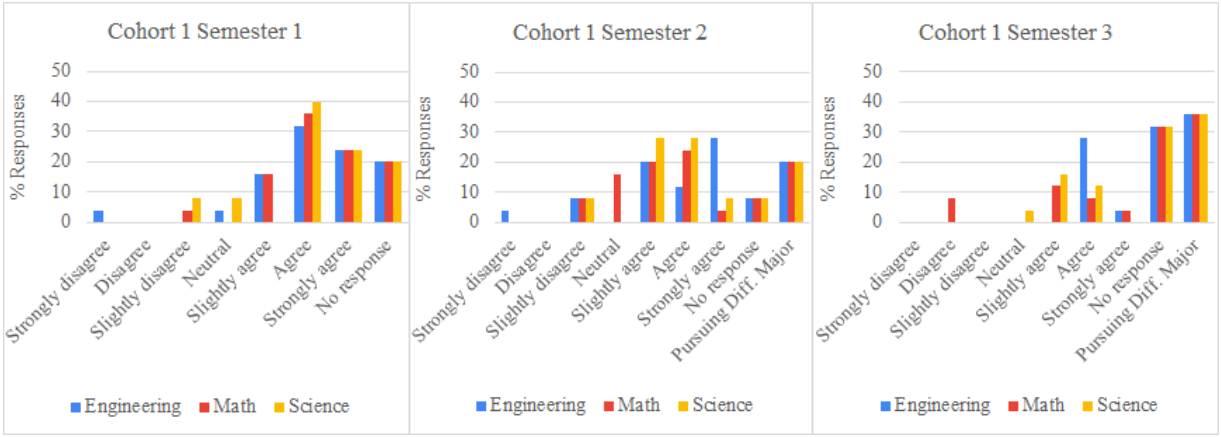

Figure 6: Cohort 1 global affect survey responses to the question "My feelings/attitude about _____ are generally positive" across semesters 1-3. These data are from the (n=25) students who responded to at least one end-of-semester survey.

Attitudes towards math and science shift across the semesters from very few negative attitudes in the pre-survey to a few slightly disagree and disagree during each of the later semesters. This seems due to students' individual experiences in their math, physics (year 1), and chemistry (year 2) courses. Certain students reported having professors they struggled to learn from or stressful experiences based on course organization.

Students' perception of their affective regulation skills also shifted across semesters, as shown in Figure 7. Particularly notable are the results from the end of semester 2: of the three students who replied either "disagree" or "slightly disagree" to the prompt "I have the skills to manage the emotions that arise while problem-solving," two had decided at that point to pursue different majors the following semesters. Moreover, these were the same two students who had significantly negative indicators for engineering identity.

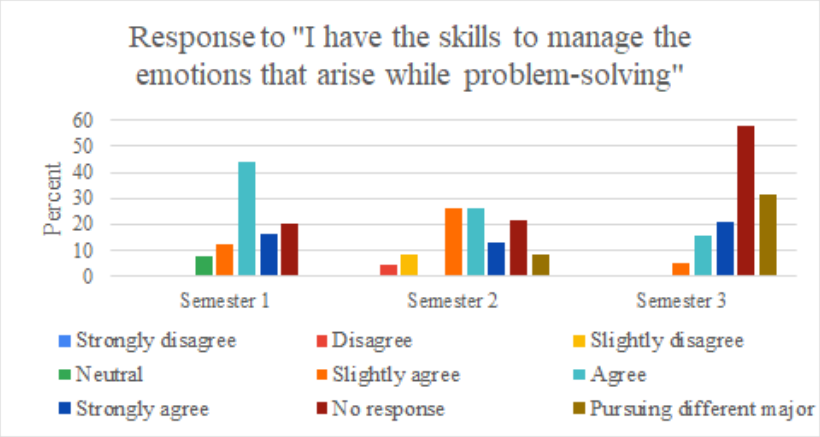

Figure 7: Cohort 1 response to the affective regulation survey question across semesters 1-3. These data are from the (n=25) students who responded to at least one end-of-semester survey.

Discussion and Conclusions

Our initial survey findings show a trend of many students entering an engineering degree with strong positive global affect towards math, science, and engineering (although a few students were weakly negative in their global affect towards engineering). As students proceed through their coursework, we see these attitudes shift over the course of the first three semesters. For students who remained in engineering and continued to reply to our surveys, global affect towards engineering became very positive (all participants replied “agree” or “strongly agree” to the prompt), while some of the same students remained neutral or even negative in their global affect towards science and mathematics.

This positive global affect towards engineering seems to correspond to relatively strong engineering identities for the students who stay in the major. These findings are similar to those in Godwin’s study [11] that saw math and physics identities were important for choosing engineering. Conversely, we also see students selecting strongly disagree or disagree to global affect or identity questions leaving engineering in the subsequent semester. For students who left engineering after two semesters in this cohort, we also see that as the coursework became increasingly difficult (as established by students in the interviews), their lack of affective regulation may have played a role in their decision to switch majors. The links between global affect and identity suggested by our results here are not surprising, especially given that work on identity often focuses primarily on students’ beliefs about their performance, competence, recognition, and interest [2], [11] rather than on their actual demonstrated performance, competence, and so on.

Our conclusions here are limited due to the small number of participants in our study for a quantitative study, which is made worse by the gradual lack of participation. For our project as a whole, the majority of our data is qualitative in nature and what we have presented here represents a small portion of our results. As discussed above, the link between global affect and

identity is relatively unsurprising; in ongoing work with the interview transcripts, we are examining more closely the influence that students' local affect has on their formation of an engineering identity, as well as continuing to focus on the role that meta-affect plays in students' experiences.

Acknowledgements

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