Embedded Affective Assessment

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***Abstract*—This work-in-progress paper provides initial details in an early and ongoing process to embed affective assessment of student development throughout a new engineering program. Assessment of student knowledge, skills, attitudes & values, and behaviors is an important part of course and program assessment. Affective assessment covers the attitudes, values, and behaviors that students develop throughout their undergraduate engineering career. The overarching framework that guides the affective development, and therefore the affective assessment, of undergraduate engineers in this program is the Community of Practice framework. Current status of the affective development and assessment program is shared, including results from an engineering beliefs and identity survey and methods for incorporating the Community of Practice framework into the undergraduate engineering curriculum.**

Keywords—assessment, learning outcomes, affective attributes, community of practice

I. Introduction

Assessment in engineering education goes beyond technical content. Affective attributes such as grit, mindset, identity, and belonging have made headlines recently while others, including students' learning styles and personality tests, have been a part of engineering education research and practice for years. Development of student affective attributes is something that is expected to occur during college, but these attributes are not often intentionally measured and tracked as part of the embedded assessment of an engineering program.

This work in progress paper is intended to introduce a new School of Engineering and their work to incorporate affective assessments longitudinally throughout the curriculum. Under the overarching communities of practice framework, a variety of affective instruments will be implemented to explore what factors support student success in engineering. Implications of this long-term project include a better understanding of how to encourage engineering students to become engineers, particularly those from underrepresented populations. The program will also be able to provide insight into how to successfully integrate longitudinal assessment of affective factors throughout an undergraduate engineering education.

II. Background

Engineering is more than technical content knowledge. To become an engineer, undergraduate students are expected to exhibit an understanding of teamwork, ethics, lifelong learning, and an understanding of contemporary issues under ABET accreditation criteria [1]. The revised ABET criteria also include a definition of engineering design which describes an iterative problem-solving process including identifying opportunities, considering risks, and making trade-offs to obtain "a high-quality solution under the given circumstances" [2]. Engineering students must be able to incorporate these skills into their engineering design processes. In addition, they must value these skills and include them into engineering problems automatically.

To persevere in engineering, a variety of factors come into play, including student beliefs about engineering and students' engineering identity. As an example of an influential belief, engineering is often considered a difficult major. Similar to the skills and attitudes above, beliefs like this are also not technical content knowledge.

A. Assessment

Assessment can refer to a variety of methods and components. Terenzini [3] introduces a taxonomy to understand assessment on the individual and group levels, formative and summative purposes, and for knowledge, skills, attitudes & values, and beliefs as shown in Fig. 1. This program focuses on individual development of engineering attitudes, values, and beliefs and group assessment of these factors.

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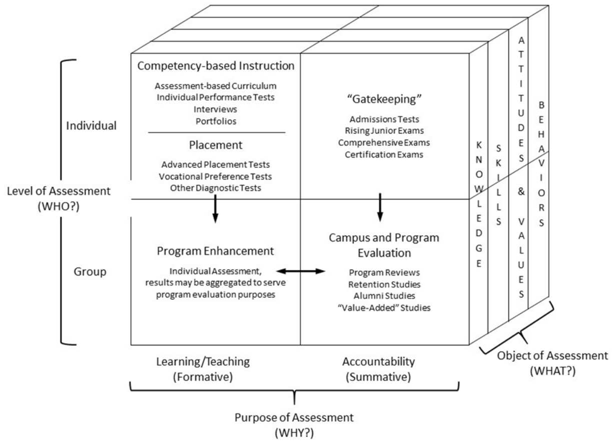

Fig. 1. A Taxonomy of Approaches to Assessment, adapted from [3].

B. Context

The Campbell University School of Engineering is a new program within a small private liberal arts institution. This institution is situated in a rural environment and has a religious affiliation. Due to its proximity to military bases and history of serving active members of the military and veterans, a substantial proportion of students are service members or veterans. In addition, the faculty does not align with traditional engineering demographics, with a majority of engineering faculty identifying as female. Beyond the unique context and demographics of the population of the School of Engineering, there is an intentional effort to develop the values, attitudes, and beliefs of the engineering undergraduates through in-class and out-of-class activities. There is a large body of research on affective attributes of traditional engineering students and students in certain minority groups, however, this research effort is aimed at understanding and evaluating the School of Engineering's program while adding to the body of knowledge relating to affective attributes of engineering students in nonstandard contexts.

III. Theoretical Frameworks

There is one overarching framework that guides the affective development and assessment of undergraduate students. This framework is the Community of Practice (CoP) framework which incorporates multiple affective components including the three important identity constructs of interest, performance/competence, and recognition [4].

A. Community of Practice

The community of practice framework is used as the broader framework to unify the range of affective measures considered in this project [5]. Communities of practice are often thought of as hobbyists or those meeting to further a specific personal or professional interest (e.g. teaching communities of practice). A department in a university, in this case, an engineering department, meets the definition of a community of practice in that it has a specific domain, engineering, a defined community, the students and other members of the department, and the practices are those that are embedded in the culture of studying engineering and becoming practicing engineers. We have defined our community of practice in another work to operationalize our community of practice and better define the practices of our community of practice [5]. Affective components such as belonging and identity are clearly interwoven in a community of practice framework, making this a strong framework to unify assessment of affective attributes across the curriculum.

IV. Methods

The methods discussed here will cover the methods used in creating the engineering Community of Practice and the data collection currently underway.

A. Community of Practice Implementation

As part of the Community of Practice model, students in their first year are required to take part in activities inside and outside of the classroom that orient them to the three main aspects of a Community of Practice: a content domain (engineering), a community (the School of Engineering), and the norms of that group (engineering and School of Engineering values, attitudes, beliefs, and practices) [5]. As students progress through the various levels of a CoP, from legitimate peripheral participation to active members of the engineering CoP, they gain the recognition of others along with the engineering competence that are integral components of their engineering identities [4]. Students are able to continue to take part in CoP activities, including working on personal projects in the School of Engineering facilities, taking part in engineering student organizations, and attending external activities such as industry tours and conferences. A further discussion of how the Campbell University School of Engineering community of practice has been developed and implemented can be found in [6].

B. Engineering Beliefs and Identity Survey

The survey currently in use is adapted from the "Are College Students Adults?" survey first published in [7] and later adapted by [8] to be specific to engineering. This survey asks whether students believe that specific criteria are required in order to be an engineer (e.g. being able to make competent design decisions, speaking/communicating using accurate technical terminology, etc.) and whether they feel that they have met each criterion at this point in time. The survey was further adapted for use in this program to include specific courses and required components of the curriculum. Excerpts from the survey are shown in Fig. 2.

In addition to asking students whether they find these criteria necessary in order to become an engineer, the survey asks whether the students consider themselves to be engineers and whether or not they feel that they are capable of meeting each criterion. The second half of the survey incorporates questions relating to various aspects of their time as an engineering undergraduate. These questions relate to CoP components, including questions regarding active involvement with engineering student organizations, and whether or not they feel that they have a supportive group of peers in engineering. Optional professional activities such as internships and competition teams are included on the survey in addition to expected and required activities such as engineering classes. The survey is modified for each year in the program to include the classes that students should have taken during that academic year. Results from the first iteration of this survey can be seen in [6].

Do you consider yourself to be an engineer? (circle one)	Yes	In some ways yes, in some ways no.	No
Do you plan to work, conduct research, continue study, or teach engineering for at least three years after graduation?	Yes	Unsure	No

Indicate whether you feel each of the following is necessary to be considered an engineer. Then, mark whether you can do each thing at the current time.	**Neccesary?**		**I am capable of this now.**	
Being able to make competent design decisions	Yes	No	Yes	No
Being able to teach engineering content to another person	Yes	No	Yes	No
Speaking/communicating using accurate technical terminology	Yes	No	Yes	No
Feeling confident in engineering work without confirmation from others that the approach is technically sound	Yes	No	Yes	No
Making moral/ethical decisions considering all factors	Yes	No	Yes	No
Accepting responsibility for the consequences of actions	Yes	No	Yes	No

For each question, circle the response on the right that best describes you.	**N/A**	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
I am actively involved with an engineering student organization	0	1	2	3	4	5
I have a supportive group of peers in engineering	0	1	2	3	4	5
Professional Development events made me feel more like an engineer	0	1	2	3	4	5
Service events made me feel more like an engineer	0	1	2	3	4	5
Working on personal projects in the Makerspace or Fab made me feel more like an engineer	0	1	2	3	4	5
Materials Science (ENGR240) helped me understand what engineering is.	0	1	2	3	4	5
After completing ENGR240 I felt more like I was an engineer.	0	1	2	3	4	5

Fig. 2. Selected questions from the modified Engineering Beliefs and Identity Scale.

C. *Participants*

Not all students in the School of Engineering have taken this survey. The survey was administered at the end of the Spring 2018 semester to students taking the second course in the two-course fundamentals of engineering (first-year) sequence and second-year students in circuits 1. Typically, these are students who entered the School of Engineering with all appropriate prerequisites and who have followed the expected course sequence. In total, 24 of the 27 eligible first year students and 36 of the eligible 40 second year students completed the survey. The surveys were administered in the same class session as the course evaluation surveys. Prior data was collected at the end of the Spring 2017 semester to students completing their first year; 35 of the 37 eligible students responded. To ensure anonymity and encourage students to report truthfully, some demographic data is collected, however no student names or identifiers are connected to these surveys; individual student responses are not tracked across years.

V. Results and Discussion

At this point in our program of affective assessment, we have one instrument implemented and a program of integration to our engineering CoP underway.

A. *Engineering Beliefs and Identity Scale*

Thus far, one instrument has been embedded into the curriculum, the Engineering Beliefs and Identity Scale. Through this instrument, we are able to track how students self-report their understanding of engineering and whether or not they feel that they themselves are engineers. The main question relating directly to engineering identity is: "Do you consider yourself to be an engineer?" In the cohort of students who have completed two years in the program, students have gained a somewhat stronger engineering identity, however many students still feel that they may or may not identify as an engineer. Overall, 11% (4 of 35) felt that they were not an engineer in Spring 2017 while only 3% (1 of 36) indicated the same in Spring 2018. 74% (26 of 35) were unsure in Spring 2017 compared to 56% (20 of 36) in Spring 2018, and the number of students who identified as engineers increased from 23% (8 of 35) in Spring 2017 to 36% (13 of 36) in Spring 2018. The 2018 first year students identified more strongly as engineers when compared to the 2017 first year students, with 13% (3 of 24) responding that they did not consider themselves to be an engineer, 46% (11 of 24) responding that they were not sure, and 42% (10 of 24) responding that they considered themselves to be engineers.

B. *Community of Practice Integration*

Much of the CoP facilitation takes place in the first year of engineering study. For students who are "on track", or taking the expected course sequence, developmental activities include a seminar class to help develop a personal understanding of and identity in engineering in addition to the values of the SoE, a foundational engineering course that incorporates teamwork and an understanding of engineering design, and a variety of required extracurricular professional development and service opportunities. Students are able to enter into the CoP and bond with others over their shared experiences. It is anticipated that this yearlong facilitation strongly helps students to develop a sense of connectedness to the program and identity as an engineer. This hypothesis is supported by the preliminary results.

Some questions in the Engineering Beliefs and Identity Scale relate directly to aspects of the community of practice, from having supportive peers to participating in non-mandatory discipline-specific organizations. Of the students who completed the survey in the first and second year cohorts, all but one student chose "agree" or "strongly agree" when asked whether they have a supportive group of peers; the student who did not agree was neutral. In their second year, students are not required to participate in professional development or service activities, many of which are provided through engineering student organizations. Students who are strongly enmeshed in the CoP are likely to continue to choose to participate in these community- and discipline-focused events. Of the 36 second year students, ten indicated that they are not involved in engineering student organizations, while an additional nine answered "neutral". The remaining seventeen students agree or strongly agree that they are involved in engineering student organizations, continuing to take part in domain- and community-focused offerings that strengthen the engineering CoP. It is important to note that these results come only from those students who are considered “on track”, students who have completed the coursework as expected and have been fully immersed in the intended engineering onboarding experience.

There are, however, three groups of students who do not share the same initial integration into the engineering CoP. Students who enter into the program with low ACT or SAT mathematics scores must take an initial course and at least one mathematics course before they are able to enter into the typical first-semester courses with the a co-requisite mathematics course. This is a smaller cohort with lower, though comparable, retention rates. Transfer students, those typically entering with two-year degrees, have many prerequisite courses complete and take first- and second-year engineering courses simultaneously. The third group of students who may not have the same yearlong introduction to the CoP are students who are not taking the courses in their expected sequence.

In an ideal situation, these three groups of students will have equal outcomes in terms of technical knowledge, skills, values, beliefs, and attitudes. Future work will analyze each of these groups to understand any differences that exist in overall outcomes. The findings will inform programs intended to integrate students in the engineering CoP to ensure equivalent outcomes for all students.

C. *Impact*

Data collected through the affective assessment program has the potential for a variety of impacts within the school and in the engineering education community.

Internal to the program, the information is used to determine whether optional activities should be required, whether courses or required activities should be revised, and to track how various groups of students are progressing in the development of their engineering beliefs and identity.

The program of affective assessment can also contribute to the engineering education research community. The unique context of a small, private, southern, religious, liberal arts institution with a large population of nontraditional and Hispanic students will allow for insights into whether existing literature holds up in this context. It will also contribute to the body of literature through the longitudinal study of change in students’ engineering identities throughout their engineering undergraduate studies.

VI. Future Work

Future work includes continuing to implement the current survey more broadly to capture the experiences of all students. The current implementation captures only students who are on track and only at the end of the year. Changes over the summer and during the school year are not captured, and students who for any reason are not in the expected course at the end of the year are also not surveyed. Timing of the survey to capture an accurate picture of development (without inducing survey fatigue) and implementation to gather data from students who are not in the expected course at the time of surveying will be evaluated.

Additional affective research on our students will include developing an exit interview protocol that incorporates questions regarding students’ values, attitudes, and beliefs, including beliefs about engineering and personal engineering identity identification. Students choose to leave engineering for a variety of reasons. For those students who are transitioning to a new major but not leaving the university, we would like to understand their affective beliefs regarding engineering and their perceived “fit” as engineering students. Exit interviews will help us to understand the values, attitudes, and beliefs of students leaving engineering.

We are also considering entrance interviews for those students who are choosing to transition to engineering from another major. Transitioning to engineering is a difficult proposition for many students, potentially adding years of study and debt to their college experience [9]. Focus groups of incoming traditional first-year students will also build an understanding of why students choose engineering in general and this institution in particular. Understanding the affective factors involved in choosing to enter into engineering will help to identify and recruit potential students as well as facilitate integration into the engineering community of practice.

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