Work-In-Progress: What is engineering? First-year students' preconceptions about their chosen profession

Introduction

Inherently, one can assume that students enroll in engineering programs to become engineers (though they might not end up as one). However, they don't become an engineer overnight. There is an entire process by which this "becoming" enfolds, requiring more than just the acquisition of technical knowledge and key skills. The process includes the development of professional identity, which is the understanding of the profession and its associated roles and responsibilities on a continual basis [1]. One outcome of the first-year experience is for students to develop an engineering identity, which has been shown as one of the key indicators for persistence within academic and professional spaces [2].

Professional identity can be broken down into three main processes: acquisition of disciplinary knowledge, development of social network of like-minded professionals, and sensemaking [3], [4]. While the first two items are self-evident, the third deals with the ability of defining a self-narrative that describes how they fit in the profession.

Students in the past decade have been exposed to a variety of informal and formal STEM programming, as current efforts toward broadening participation in engineering has been a main focus of governmental funding and subsequent research efforts [4], [5]. Experiences such as formal K-12 engineering courses, afterschool robotics programs, or informal engagement in engineering-focused museum exhibits, provide opportunities for students to make sense of what engineering is [6]. However, this sensemaking is highly individual and dependent on the quality of the personal experience. It is expected in many first-year programs that students will come in to the first day of class with preconceived concepts of engineering. These preconceptions might be in direct opposition to actual engineering concept. A conceptual shift on part of the students may be required in order to assimilate into their professional identity.

But before one can look into the formation of engineering identity, there needs to be a baseline to determine what types of preconceptions first-year students come in with. Note that this study focuses on conceptions and not perceptions, though they are often used interchangeably in research. Conceptions deal with the formation of understanding, whereas perceptions are based on sensory input.

How then do students conceive engineering at the start of their first-year of post-secondary education? This paper will discuss the results from students' written work as it applies to their preconceptions about engineering at the beginning of their collegiate career, where they have received no formal ABET accredited instruction regarding engineering. This is part of a larger

study that evaluates broad concepts about engineering during a four-year period (beginning and end of first year, end of final year).

Methods

This exploratory qualitative study utilizes content analysis to analyze engineering preconceptions of first-year students. Data was collected from a medium-sized private university located in the Pacific Northwest. During the first class, students were asked to write a one-page essay using the prompt of: "what is engineering?". This simple prompt allowed for an exploratory analysis of the student provided responses. Essays from 543 engineering students, from three cohorts (2016-2018) were collected.

Content analysis was used to analyze the essays, with focus on thematic patterns regarding conceptions of engineering [7]. Patterns were identified through a rigorous process of data familiarization, data coding, and theme development. Each essay was read multiple times ($n > 3$). The codes were developed based on semantic reflections of the explicit content, such as sentences that started with "engineering is". Labels were identified for inferred concepts about engineering (e.g. "I am anxious about taking the higher-level math courses required"). The concepts then were examined and collated together into broader patterns of meaning. These patterns of meaning were checked against the greater data to refine into specific themes.

Results

Students' preconceptions of engineering centered around five key thematic areas: knowledge, perception, impact, method and performance (Figure 1). Students often eluded to content *knowledge* that they expected engineers to know. Oftentimes this was more broadly addressed as math and science in a very generic way. Such as "engineering is applying math and science". This general stance is an oft repeated adage, that while true, doesn't paint the entirely of what engineering is.

The second theme to emerge deals with student-imposed *perceptions* of the field, situated in two environments: academic and professional. For the academic endeavors, students perceived engineering to be difficult and demanding, yet a worthwhile endeavor. Many students expressed anxiety with their choice of major.

Students responses often connected to the output of engineering endeavors, they want to "create" or "invent" something that will make some kind of *impact*. One student explained that "creations are objects that an engineer produces in order to make the world a better place". While this definition is limited to artifacts that are tangible in nature, it excludes several other end-products in the engineering world.

Another reoccurring theme demonstrated the ways in which engineers enact their jobs, as in their *methods*. Many individuals connected engineering to a "very" hands-on career path, in which concepts of "fixing", "repairing" and "inventing" were common descriptors. Skillsets also mentioned, such as programming, problem solving, critical thinking, creativity and the ability to work in teams.

One of the largest thematic areas was dedicated to perceived *performance*. Largest among this area was anxiety surrounding the idea of failure. Students also expressed feelings of intimidation on the complexity and "difficulty" of the course materials required to obtain their degree.

Discussion

Results from this analysis indicate that students come into engineering with a variety of different preconceptions about engineering. These preconceptions are the result of experiences prior to entering post-secondary education and would necessitate additional studies to determine impacts relative to specific programs. However, with the popularization of STEM programming in P-12 environments, this would be a worthy endeavor. This preliminary analysis is part of a larger study that will look more deeply into these preconceived notions of engineering. Future work will delve into comparative analysis looking at differences relating to the concepts defined here at different stages of their academic journey.

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