

Preliminary Findings on Students' Beliefs about Intelligence

Abstract

The goal of this project is to better understand the beliefs that undergraduate students hold about their own intelligence and how these beliefs change during their undergraduate engineering education. The research team has used the theoretical framework established by Carol Dweck on Mindset and how different fixed and growth mindsets affect success. Fixed mindset individuals believe that their intelligence is an unchanging trait, while people with a growth mindset believe that through effort they can grow and develop greater intelligence. Prior researchers have shown that individuals with a growth mindset respond to challenges with higher levels of persistence, are more interested in improving upon past failures, and value criticism and effort more than those with a fixed mindset.

The team developed an interview protocol from the theoretical framework. Then the team piloted the protocol and subsequently modified the protocol multiple times to ensure that the interviews provided rich qualitative data. Analytic memos were used to analyze and modify the piloted interview protocols. Once the final protocol was established, first-year and senior students were recruited to provide cross-sectional insight. The team also recruited using purposeful sampling to ensure that women and underrepresented minorities were included. To date, 19 interviews have been conducted with the final protocol. Of these interviews, four have been coded in detail using the "Attitudes, Values, and Beliefs" coding system. A codebook has also been started to categorize and interconnect the themes in the interview transcripts. This paper provides details of the protocol and coding process as well as preliminary findings on the themes extracted from the student interviews.

Scope

This project is part of a Research Initiation in Engineering Formation National Science Foundation grant. The overall goal of this work is to both study students' beliefs about intelligence as well as train new researchers in the field, including a professor and graduate student with no prior experience or training in conducting engineering education research. The purpose of this paper is to detail the interview and coding process as well as provide insight into themes extracted from student interviews to improve undergraduate education.

Using a cross-sectional, qualitative study design, we are trying to answer the following research question and subquestions:

How do undergraduate engineering students characterize their beliefs about the nature of intelligence?

- How do students perceive the nature of their own intelligence?
- How do student perceptions change over time during undergraduate formation?

For the full project, we will have interviews from 20 first-year and senior engineering students. When students were selected, half identified as first-year students and half identified as senior

students. Thirty two percent of participants identified as women, 68% identified as men, and 5% did not self-identify. Ninety-five percent identified as US citizens and 5% identified as international students. Eighty-four percent of students identified as white, while 16% identified as multicultural. Within the College of Engineering where the study took place, 18% of enrolled students are women, 12.1% of enrolled students are multicultural, and 6% of enrolled students are international. Wherever possible, students were selected to provide as close a sample to the environment around them as possible. Women were oversampled because one of the most responsive recruitment groups was an Engineering Sorority. Since women are often undersampled the team decided that this could provide useful insight. Previous research has shown that when women are underrepresented, mindset can have amplifying effect on their success (Good, 2012). Therefore, having a sufficient sample of women is useful to provide insight into this effect. This paper describes process of analyzing the interviews of these students.

Theoretical Framework

Mindset is a framework developed by Carol Dweck (Dweck, 2006) that explains how one's beliefs about intelligence affects their success. Someone who holds a fixed mindset believes that intelligence is static and does not change (i.e., a person has a fixed amount intelligence). Whereas, someone with a growth mindset believes that intelligence can change and is correlated with one's directed effort. These beliefs can be implicit, strong, and deeply-held. Additionally, these beliefs are not all-or nothing, but rather they are contextual. For example, a person may have a fixed mindset about their mathematical ability while maintaining a growth mindset about their linguistic ability, or vice-a-versa.

These beliefs can manifest different behaviors, which in turn can affect their success, particularly in academics (Dweck, 1990). Previous research has shown that beliefs about intelligence can be tied to: 1) Goals and motivation, 2) Beliefs about effort, and 3) Responses to challenges (Blackwell, Trzesniewski, & Dweck, 2007). Since these beliefs can be implicit, we use qualitative methods to gain a deeper understanding not only of students' beliefs but how it affects their behavior and success. The framework was used to develop an interview protocol as shown in Figure 1. **When coding transcripts, particular attention is paid to attitudes, values, and beliefs related to these distinct aspects.**



Figure 1. Distinct aspects of the Mindset framework used for the development of our interview protocol

Background and Motivation

Our motivation to untangle the beliefs that students hold about the nature of intelligence in order to retain more students, increase learning, improve students' classroom experience, and prepare them for taking on world challenges. To meet the needs of the 21st century, we need more engineers that are well-prepared to take on the changes in our society (National Academy of Engineering, 2004). Table 1 summarizes some of the ways that a student's mindset can manifest in the classroom. In the bottom row, we have provided a hypothetical perceived relationship that students may develop with their instructor.

Fixed Mindset	Growth Mindset
Believe ability (intelligence) is fixed	Believe ability (intelligence) can change
Fear being wrong	Accept challenges willing
Focus on end result (being perfect)	Focus on process (seeing progress)
Blame external sources for failure	Take responsibility for their own learning
Recognize "naturals"	Recognize hard work
Likely give up when faced with adversity	Practice grit and mental toughness
Instructor: <i>"you have permanent traits and I'm judging them"</i>	Instructor: <i>"you're a developing person and I'm interested in your development"</i>

Table 1. How beliefs about intelligence may change student behavior and affect their interaction with their professors

We want to further our understanding of students' beliefs about intelligence and how these beliefs affect undergraduate engineering students' experience and choices. We are also interested to determine if and/or how these beliefs change throughout their undergraduate education. Previous studies have utilized the Mindset Framework within the context of engineering education. For example, researchers have used quantitative measures to provide evidence that students who maintain a growth mindset are more likely to utilize active learning strategies (Stump, Husman, & Corby, 2014). Another study that utilized quantitative measures of students' beliefs about intelligence supports the use of first-year design tasks to mitigate the formation of a fixed mindset in engineering students (Blackwell et al., 2007). This current study aims to fill the gap that exists when it comes to a qualitative understanding of students' beliefs about intelligence and how undergraduate engineering education may change these beliefs.

Learning and asking about others' beliefs can be sensitive and difficult. There are cultural norms associated with intelligence and how we discuss them (Kruger & Dunning, 1999). For example, we don't often tell strangers how smart we think we are. Another difficulty is that subconscious beliefs can differ from espoused beliefs. Within a single interview students may change their espoused beliefs. The sensitivity of this topic of intelligence provides a challenge for collecting meaningful data about related beliefs. Therefore, it is very important that the interviewer does not show bias that may influence students' answers. Using qualitative coding to analyze those beliefs, we are coming closer to an understanding of undergraduate engineering students' beliefs about intelligence.

Coding

In order to analyze the transcripts of the interviews, the researchers are utilizing Attitudes, Values, and Beliefs (AVB) coding. This coding lens, including the definitions for attitudes, values, and beliefs, have been implemented in accordance with the handbook for qualitative coding by (Saldaña, 2016). An attitude is "the way we think and feel about ourselves, another person, thing, or idea." (Saldaña, 131) A value is "the importance we attribute to ourselves, another person, thing, or idea," (Saldaña, 131) while a belief is "part of a system that includes our values and attitudes, plus our personal knowledge, experiences, opinions, prejudices, morals, and other interpretive perceptions of the social world" (Saldaña, 132).

AVB coding was selected because while a student is less likely to bluntly state a deeply held belief, attitudes and values are typically readily given (McNeill, Douglas, Koro-Ljungberg, Theriault, & Krause, 2016). These attitudes and values can themselves be complex, and they can hint at, elucidate, or even contradict their beliefs, forming a clearer picture of the students' belief sets. For example, the interviewee who picked the pseudonym "Janice" routinely went back and forth between saying that she knew her grades were "not the best definition of doing well," and espousing that grades were "a measurement of your success." Another student, "Edoras," would use his grades as his primary tool for self-evaluation, especially as an indicator for having learned classroom material. When asked about the importance of grades, however, he said that a good grade "doesn't necessarily mean that you have learned." In both cases, it seemed that the student had been taught that the acceptable thing to believe is that grades do not completely define a student, yet they were unable to tear their deeper evaluations of themselves away from the grades they received.

When coding, the primary researcher and at least one other researcher read through an interview, mark, copy, or make note of any attitudes, values, or beliefs they find and write analytic memos (Saldaña, 44) where appropriate. Then they meet and discuss their findings, making sure that nothing of importance is missed. Following that, codes are assigned to the different attitudes, values, and beliefs noted, thereby categorizing and organizing all codes.

Codes are drawn from a codebook, which is created early on and updated frequently for the first few transcripts, and less frequently as needed after. Thus far, only four transcripts (selected for the range of views) have been fully coded and the codebook is still being updated frequently. In

general, the codes that our research team generated are words or short phrases to organize the attitudes, values, and beliefs expressed by the students. For example, some students will blame the teacher for a bad grade on a test, while others will assume that they have not taken the necessary actions to prepare themselves. Both could be grouped under the code “Responsibility,” though they might be further sub-coded into “Denying Responsibility” and “Accepting Responsibility.” Also related to exam performance, students reminiscing about a good test grade or an accomplishment might be coded as “Success.” Sub-codes can also be combined or connected in new ways. Codes that seem separate at first may be later combined under a more encompassing category, like “Competition” and “Prestige” might be joined under the code “Judgement.”

Preliminary results

The research team developed the first draft of the codebook based on the first three coded transcripts: “Alice,” “Ivan,” and “Janice.” These transcripts were chosen because they felt like the most strongly indicative examples of Growth Mindset, Fixed Mindset with high self-confidence, and Fixed Mindset with low self-confidence, respectively. Alice and Janice are first-year students, while Ivan is a senior. Below is an example of an emerging theme with its respective code and sub-codes:

- Judgement
 - Judgement of others
 - Judgement from others
 - Judgement of self

This code is intended to encompass situations such as a student passing judgement on their peers for their test grades, fearing the same judgement from their peers or professors, or judging themselves for success or failure on a test or project. Other initial codes included the following:

- Success
- Self-Worth
- Responsibility
- Validation
- Motivation
- Societal Values
- Interest
- Competition
- Prestige
- Effort

As work on the codebook progressed, the various codes were consolidated to three large themes: Judgement, Effort, and Motivation. These themes are linked and interconnected as shown in Figure 3. While the categories from the coding are similar to the framework, they

link together differently. Of particular interest in how prevalent fear of judgement is and its connection to the other categories.

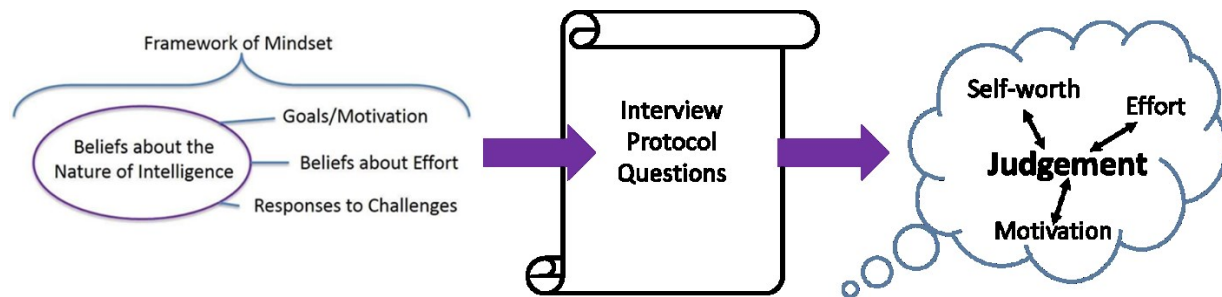


Figure 3. The processes of developing a protocol and the results of data collection for one theme.

Judgement

Judgement encompasses not only a student's thoughts about others judging them, but their own judgements of others, and their judgements of themselves (self-worth). Some students, such as Ivan, claimed to not be terribly worried about judgement from others. He claimed that his peers' opinions of him had no effect on him. When asked about judgement of professors, however, his answer was more interesting: he claimed not to care, but the first thing he said in explanation was that "grades are objective." He went on to explain that in engineering courses, a grade is only based on whether or not the answer is right. Despite claiming not to care whether or not his professors thought he was smart, his explanation for this attitude was that his professor had adequate evidence that he was smart. In other words, he said that that he feels he could not be judged in a negative light because this evidence could not possibly exist. Janice, in contrast, spoke a great deal about judgement from her mother. She often described fear that her mother would be "mad" or "disappointed," and when she lost a race; she felt that her mom "thought I was just, like, quitting." When asked, however, she admitted that her mother had "never done anything to make me think that." She also feared professors judging her on the chance that they might be less willing to help her when she asked. Alternatively, Alice was of the opinion that intelligence is a subjective term, and passing judgment about it for someone else is largely meaningless. When asked about their study habits, all three participants compared themselves unfavorably to other students, though Janice seemed the most troubled by it. It became readily apparent that not only their feelings of others' judgement of themselves, but also their own judgements of others, factored into their judgements of themselves. Though separate from the Mindset framework, this become a significant factor in motivation and effort.

Motivation

Motivation, as described in Mindset, was able to be subcategorized into two types: internal and external motivators. Internal motivation codes included learning, interest, success, pride, self-worth, and self-responsibility. All three students spoke of having internal motivating factors, although Alice focused on these motivating factors much more than the other two. External motivation codes included grades, prestige (looking smart), validation, money (whether from a

career or a scholarship), competition, and judgement. Again, all three were motivated by such external things, but Janice in particular was concerned about prestige, competition, and judgement. An interesting thing to note was their explanations for their motivation to be an engineer. Alice's answer was perhaps a bit vague, but impassioned: she desires to learn constantly, and the idea of being an engineer and learning new things by figuring out how to do something previously unknown. Janice started as though she thought she knew what she wanted—to work in the medical field—but when asked what she wanted to do there, she simply became lost. Ivan, on the other hand, felt that he had been placed there by his upbringing. He was happy to stay an engineer, but his initial response was “I wouldn't know what else to do to be honest.”

Effort

The theme of effort was divided between the students' views on their own efforts and their views on the efforts of their peers, but it could also be looked at divided between successful and failed efforts. When asked to describe students who succeeded in school, with and without working hard, Janice described the hardworking student as “very smart even if they have to work hard.” The hypothetical carefree student (described in the interview protocol), however, was met with jealousy: “Why can't I be like that?” This envy was surrounded with comments on the hypothetical student's low work ethic and inability to hand in homework. The envy transitioned into harsh judgment. Ivan supposed that the hardworking student might be “lower on the scale” than him in that class, though he guessed they might be better in another subject. The student who did not work hard was met with overall approval, and he said that it was likely to be in the circumstance of the subject they were best at, and that everyone has such a class. Alice, contrastingly, rejected the questions altogether. She holds that “smart” is a subjective term defined by the person describing it, and that everyone is smart, just smart in different ways. Her own subjective view of smart rejects the idea of tying intelligence into the amount of effort needed to do something, but instead is reflected in an individual's own conscious choice to try and learn more.

When Ivan was asked about a class he had to work very hard in, he claimed that the reason he had to work so hard was that the professor was not good at teaching, deflecting responsibility from himself. In his description of a class that required little effort, he explained that his level of interest in the subject allowed him to learn with ease. Yet when asked about an experience where he was informed that he was not meeting expectations, he was unable to give an example. Janice, on the other hand, blamed her lack of background for her class that required phenomenal efforts; she was taking an advanced course on a subject she had not previously studied, while her classmates had all taken a previous course. Of her easy class, on the other hand, she claimed to have enjoyed the lack of effort needed but not gained anything from taking it. When asked about an experience where she failed to meet expectations, she described working hard to be a fast runner. In spite of making her personal record after her efforts and doing well in the state competition, her failure to place very high was taken as a sign that she would never be an “amazing runner.” Though she still runs for enjoyment and exercise, she has entirely quit doing it competitively, and when giving advice to another struggling runner, she said, “I would straight-

up lie to them” and tell them that if they put in effort, they will see results. She then corrected herself, realizing that she *had* seen results, but still thought they were not worth the effort she had put in. Alice, unlike the other two, reacted to the high effort class with “It was fun. Because it was finally challenging.” The easy class, on the other hand, she responded to with frustration because she felt as though she had learned nothing new, and it was merely a repetition of previous courses. She responded to the boredom, however, by challenging herself to be more creative with her work. Her experience with not meeting expectations was described as a class where she could not funnel interest into the subject and did not learn as much as she expected herself to learn, and the expectations she failed to meet were her own. Her advice in such a situation was to find a way to make the subject matter interesting.

Next Steps

A total of 19 interviews have been conducted and transcribed, with one more pending. The researchers will continue to collaboratively code these transcribed interviews. Through this process, using our theoretical framework the codebook will be expanded, refined, compacted, and sub-categorized. After the refinement, the codebook will be reflected on paying particular attention to the differences between the first-year and senior level participants. These reflections will be used to determine how students’ beliefs affect their learning in order to generate recommendations on improving engineering educational practices to increase retention and student learning.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. **#1738209**. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

- Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development*, 78(1), 246-263. doi:CDEV995 [pii]
- Dweck, C. S. (2006). *Mindset: The new psychology of success* Random House.

- Dweck, C. S. (1990). Self-theories and goals: Their role in motivation, personality, and development. *Nebraska Symposium on Motivation*. *Nebraska Symposium on Motivation*, 38, 199-235.
- Good, C. (2012). *Why do women opt out? sense of belonging and women's representation in mathematics*. Washington, D.C.] : doi:10.1037/a0026659 [doi]
- Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, 77(6), 1121-1134.
- McNeill, N. J., Douglas, E. P., Koro-Ljungberg, M., Therriault, D. J., & Krause, I. (2016). Undergraduate students' beliefs about engineering problem solving. *Journal of Engineering Education*(105(4)), 560-584. doi:10.1002/jee.20150
- National Academy of Engineering. (2004). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: The National Academies Press.
- Saldaña, J. (2016). In Jai Seaman J. P. (Ed.), *The coding manual for qualitative researchers* (2nd ed.). 2455 Teller Road, Thousand Oaks, California 91320: SAGE Publications Inc.
- Stump, G. S., Husman, J., & Corby, M. (2014). Engineering students' intelligence beliefs and learning. *Journal of Engineering Education*(103(3)), 369-387. doi:10.1002/jee.20051