Reactions from First-year Engineering Students to an In-depth Growth Mindset Intervention

Dr. Emily Dringenberg, Ohio State University

Dr. Dringenberg is an assistant professor in the Department of Engineering Education at Ohio State University. She holds a BS in Mechanical Engineering (Kansas State '08), a MS in Industrial Engineering (Purdue '14) and a Ph.D. in Engineering Education (Purdue '15). Her research is focused on decision-making within the context of engineering design. She is working to leverage engineering education research to shift the culture of engineering to be more inclusive of diverse individuals and more in alignment with current research on decision-making. With a focus on qualitative research methods, she is working to better understand the ways in which undergraduate engineering students experience design and ill-structured problem solving. Her interests also include neuroscience, growth mindset, engineering ethics, and race and gender in engineering. In general, Dr. Dringenberg is always excited to learn new things and work with motivated individuals from diverse backgrounds to improve engineering education.

Amena Shermadou, Ohio State University

Amena Shermadou is an Engineering Education graduate student at The Ohio State University. She received her Bachelors and Masters in Biomedical Engineering from Wright State University, in Dayton, Ohio. Her experience with teaching first-year engineering students has led to research interests in curriculum development, student empowerment and the development of holistic engineers through the collaboration with engineering stakeholders.

Prof. Amy Rachel Betz, Kansas State University

Dr. Amy Betz is an Assistant Professor and the director of the Multiphase Microfluidics Laboratory at Kansas State University. She received her PhD from Columbia University and her Bachelor of Science in Mechanical Engineering from the George Washington University. Her research aims to acquire new fundamental understanding of phase-change processes. She is passionate about research, education, and mentoring. She is also committed to creating a more inclusive engineering culture.

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Abstract

Beliefs about the nature of intelligence have been identified as a key lever for several aspects critical to academic behavior, such as motivation, beliefs about effort, and responses to challenges. Carol Dweck provides a dichotomous framework for beliefs about intelligence: most individuals tend to believe that either intelligence is something static that remains constant for an individual (fixed mindset), or that intelligence is malleable and changes with focus and practice (growth mindset). Understanding the role that these beliefs play in the experiences of students provides insight into the ways in which they may be motivated, whether or not they believe that sustained effort is fruitful, and whether or not they persist in the face of challenges.

Research has shown that interventions that teach students about growth mindset can impact the beliefs that individuals hold, at least on a short time scale. However, less is known about the more nuanced reactions of individuals when they are asked to engage specifically with the topic of growth mindset over a longer time period. This study contributes to this area of research by addressing the following research question: How do first-year engineering students react to an in-depth growth mindset intervention?

In order to address this question, two of the authors formed a Mindset focus group consisting of eight first-year engineering students. This focus group met five times over the course of a semester to discuss their reading of and reaction to Dweck's popular 2006 Mindset book. Students' written reflections captured their reaction to the learning experience, and this data was subjected to thematic analysis. Significant findings include the use of growth mindset as a tool to reflect and unpack past experiences, especially with respect to their personal experiences, the resulting behavior, and the role of external influences. Growth mindset proved to be a useful lens to reconsider past interpretations of experiences and project forward on possible changes towards a growth mindset. Students understood that growth mindset was not an all or nothing switch to be flipped.

These findings are useful for educators interested in promoting productive beliefs about the nature of intelligence. Future work in this area will include an exploration of how these beliefs change over the undergraduate experience and the development of concrete strategies for students to begin to implement growth mindset within an engineering education context.

Background

The National Academy of Engineering provides us with a particular vision for the Engineer of 2020, and these students will be graduating in just a few short years. As engineering educators, we are called to prepare these individuals to demonstrate resilience, and be life-long learners [1]. Life-long learning is critical for the development of engineering graduates who will be able to address the Engineering Grand Challenges [2] and other wicked problems of our ever-changing world. In parallel with this mission, universities also work to address student needs related to retention and inclusion. To add further complexity, engineering students now pursue an ever-widening range of career paths after completing their undergraduate degree. One common thread across these competing demands are the needs for engineering education to holistically develop resilient individuals who can maintain motivation, invest significant effort in their learning, and persist in the face of challenges. Beliefs about the nature of intelligence have been identified as a key lever across these critical behaviors linked to academic success and life-long learning [3].

Beliefs are recognized as powerful sources of behavior and various outcomes, and they are a well-established construct of interest in engineering education research. For example, students' beliefs about their own capabilities, or self-efficacy beliefs are important [4-9], and they correlate with retention in educational pursuits [10, 11]. Prior work has shown the importance of beliefs held by engineering students about the self (i.e. identity) [12-14] and how those beliefs frame their interactions with others [15]. Theory has been generated that connects students' beliefs about problem solving to how they engage with academic work [16]. Epistemological beliefs, or beliefs about the nature of knowledge, inform how individuals solve ill-structured problems [17]. In contrast to these types of beliefs that have been a focus of undergraduate engineering education research, this line of research focuses on beliefs about the nature of intelligence.

Carol Dweck established this line of research and provides a well-developed and empirically demonstrated framework for students' beliefs about intelligence and the impact of such beliefs on behavior [18, 19]. To briefly summarize her theory, a person with a *fixed mindset* believes that intelligence is static and unchanging, while a person with a *growth mindset* believes that intelligence can be developed with practice. Experimental research has shown that introducing college students to growth mindset theory predicted higher grades earned when controlling for prior achievement [20]. Differences in academic behavior as a result of beliefs about intelligence have been empirically tied to three distinct areas: motivation, perceptions of effort, and responses to challenges [3]. Beliefs about the nature of intelligence are often developed through implicit messaging and held subconsciously. Therefore, research has established links between these hidden beliefs and more observable behaviors.

First, beliefs about intelligence influence academic behaviors and achievement because students who are oriented towards a growth mindset are motivated to engage in tasks that require learning rather than seeking tasks just to demonstrate what they already know [21-24]. Second, beliefs about intelligence underlie how students perceive effort. Individuals with a fixed mindset are more likely to perceive effort as a sign of a lack of skill or intelligence, ineffective, and something they are averse to [18, 25]. In contrast, students with a growth mindset see effort as something that is useful and in harmony with their overarching goal of learning, not just of looking smart [18]. This difference manifests in behavior, as students with a fixed mindset demonstrate a strong desire to minimize the effort they put towards their academic work [26]. Finally, beliefs about intelligence have been shown to predict students' responses to challenges. Individuals with a growth mindset respond to challenges with a mastery-orientation while individuals with a fixed mindset respond to challenges with helplessness [18, 27]. For example, college students with a fixed mindset were more likely to blame a challenge that resulted in failure on low ability or intelligence than those with growth mindset; and fixed mindset students also reported being more ashamed of obtaining a low grade point average and more likely to give up in challenging situations than those with growth mindset [22]. First-year college students have been shown to be more willing to receive supplemental instruction after experiencing difficulty when they possess or are primed with growth mindset beliefs [28].

While significant extant research has provided robust evidence for the importance of beliefs about intelligence in students' academic behavior and performance, much less research has documented the role of these beliefs in the context of undergraduate engineering education. One significant study looking at beliefs about intelligence in the context of undergraduate engineering students demonstrated that students with growth mindset were more likely to adopt productive learning strategies such as active learning and knowledge-building behaviors than students with a fixed mindset [29]. Additionally, Reid and Ferguson [30] provided evidence that the presence of growth mindset beliefs may be fostered in first-year engineering through open-ended, socially relevant design projects. While these studies provide evidence that growth mindset is important specifically within the context of undergraduate engineering education, they take more of an outside-looking-in approach. In other words, they often measure students' beliefs without an explicit discussion of the theory with participants. Less is known about the reactions of undergraduate engineering students when they are explicitly asked to engage with the theory of growth mindset and relate it to their own learning experiences.

Research Question

This work contributes to our understanding of beliefs about the nature of intelligence by revealing the reactions of first-year engineering students who participated in a semester-long intervention about growth mindset. Specifically, this study contributes to the literature by

addressing the following research question: How do first-year engineering students react to an in-depth growth mindset intervention?

Research Approach

This study was exploratory and interpretive in nature. The researchers operated from an interpretivist research paradigm with a focus on exploring the reactions of participants through open-ended solicitation of their perspectives followed by qualitative analysis. The researchers also acted as participants in the collection of the data—they engaged extensively with the participants throughout all stages of the intervention. In alignment with this positioning, our results reflect the reactions of first-year engineering students to an in-depth growth mindset that were co-constructed in participation with the researchers.

Intervention

The in-depth growth mindset intervention that was used for this study was a semester-long focus group centered on the reading and discussion of Dweck's [19] popular Mindset book. This focus group met five times over the course of a semester. The basic format of the focus group was participants independently read one to two chapters of the book. Then, participants engaged in an online discussion through the university's learning management system to openly dialogue about their reactions to the reading. The prompts for this discussion were adopted from the suggested reflection questions at the end of each chapter in the text, and they are listed in the Appendix. Specifically, participants were asked to respond to the prompts in their own written reflection post as well as respond to the posts of at least two other participants. Two of the authors also posted and participated in the online discussion. Finally, the focus group met in person to discuss. The in-person meetings of the focus group were about an hour in length and occurred over a shared lunch hour on campus. Two of the authors also facilitated and participated in the in-person discussions.

Participants

Participants were provided the opportunity to join the focus group as members of the first-year, general engineering program at a large, public, Midwestern University. The opportunity to participate was announced in all three sections of introductory general engineering courses offered that semester. Ten first-year students showed interest in joining the group, and eight of those students followed through with participation in the group. As a result, all eight student participants were first-year students in an introductory engineering program without a disciplinary focus who self-selected to participate in the intervention. Participants did not receive any incentives or compensation.

Data Collection

Data collection occurred throughout the semester-long intervention and consisted of students' written reflections submitted through the online curriculum management tool. The written reflections capture first-year engineering students' reaction to the in-depth intervention with respect to growth mindset. Both the first and third authors participated in the reading group discussions and reflections as facilitators of the intervention. Upon completion of the data collection, all the data was de-identified and students were assigned pseudonyms.

Data Analysis

The second author, with support from an undergraduate researcher, performed the data analysis on de-identified data and without having participated in the intervention. The researchers worked separately to develop codes for emergent themes based on the written discussions from participants. Each researcher conducted a line-by-line analysis of the written discussions. The researchers sorted the data by student, common trends, and chapters of the book. Each researcher focused on the emerging trends in the responses related to fixed and growth mindsets. After each researcher completed their separate analysis, the researchers met to discuss their codes to build dependability into the coding process. Where the researchers disagreed on coding, discussion with the full research team resulted in eventual convergence on the themes. After discussing with the full research team, the researchers re-coded the data separately to ensure that all emerging themes were captured. The researchers discussed their re-coded data and found that their themes aligned for how first-year engineering students reacted to an in-depth growth mindset intervention which are presented in the findings section. To add another layer of validity to their themes, the researchers calculated the inter-rater reliability using the kappa statistic for their individual themes using a qualitative analysis tool called NVivo. According to Viera and Garrett [31], the kappa statistic is used to measure inter-rater reliability when comparing two or more observers who are evaluating the same data set. The kappa statistic is a value between 0 and 1, 0 meaning less than chance agreement and 1 being almost perfect agreement [31]. Kappa values specific to themes that emerged from our analysis are presented in the findings section.

Findings

This section presents the findings of our thematic analysis. Researchers found evidence of students' reactions to reading the Mindset text and engaging in discussion about how beliefs about intelligence play a role in our lives and our learning. Student reactions fell into two major themes that we present as 1) Reinterpretation of Past Experiences through Lens of Mindset (for Fixed and Growth Mindsets), and 2) Projecting a Future Utilizing Growth Mindset
The researchers achieved *moderate agreement* for the subthemes of Reinterpreting Past Experiences through the Lens of Mindset—Fixed Mindset (kappa value of 0.50) and Growth

Mindset (kappa value of 0.59). For the second theme, Projecting a Future Utilizing Growth Mindset, the researchers received a *fair agreement* (kappa score of 0.25). These values were calculated using NVivo and interpreted in accordance with Viera and Garrett [31]. We expect that the calculation of interrater reliability was limited to moderate and fair due to the high level generality of the two themes. The themes that emerged from our data are summarized along with examples for both of these major themes in Tables 1 and 2 respectively. After each table, more thorough descriptions of the themes, including data excerpts, are included.

Major Theme 1: Reinterpretation of Past Experiences through Lens of Mindset

During the intervention, students learned about the Mindset framework including a deep understanding of what fixed and growth mindsets are and the implications of each. Their most common reaction was to reflect on their own past experiences and reinterpret those experiences by recognizing the underlying presence of fixed and growth mindset beliefs both in themselves and others. We begin by presenting some examples of past negative experiences that were reinterpreted as having an underlying theme of fixed mindset.

Table 1. Summary of first major theme in students' reactions

Major Theme	Nature of Experience	Examples
Reinterpretation of Past Experiences through Lens of Mindset	Negative/Fixed	Academic failure is tied to self-worth
		Challenges are demotivating
		Social judgement
	Positive/Growth	Others can perpetuate a growth mindset
		Academic success as a result of effort

Past Negative Experiences as an Underlying Fixed Mindset

Many of the negative experiences participants described were past experiences when the participant experienced an academic failure, such as a poor exam score, which led to feelings of discouragement, self-doubt, and low self-esteem. In general, students could recognize these experiences as rooted in the belief that intelligence was fixed and therefore academic performance is a judgement on their self-worth. For example, Cindy reflected on a salient experience in her life of including watching a friend become disheartened by failing an exam, and Franklin reflected on his own feelings of worthlessness after a poor performance on the ACT.

"*Instead of judging on her study tactics or other things she could've done differently in preparation of the exam she quickly put herself down telling herself that she wasn't smart enough*." -Cindy

"*I was devastated. I felt like the biggest failure. I felt like [my classmates] would judge me and see me as "not smart" … I felt stupid, incapable, and worthless*." -Franklin

Another example within this theme was that students described times in which they experienced challenges and lost motivation rather than working harder, which aligns with a fixed mindset. Bret and Don express this way of reinterpreting past experiences as an underlying fixed mindset both in school setting and in sports. Arlene describes her observation of this reaction to challenge in her young sister.

"*Sometimes in a math or science course, a concept comes up that just doesn't make sense to me. Everyone else seems to get it just fine, but there is something about the concept that I just can't grasp. I get stuck in a loop where I just keep putting off getting help with it.*" -Bret

"*I couldn't keep up with the more athletic students, which discouraged me from trying, which held me further back, and so on. The three years I spent experiencing this led me to sort of give up on the idea of enjoying sports at all*." -Don

"*My little sister has a fixed mindset…she is very good at [math]…this year, though, the material is actually somewhat challenging for her, and I can tell that she's losing interest in the subject. She has even told me that she thinks her math teacher doesn't like her.*" -Arlene

Students also reinterpreted past experiences as salient that included the role of others in perpetuating a belief that intelligence or ability is static through their interactions with the participants. For example, Franklin wrote about growing up playing basketball and adopting a fixed mindset towards the sport because his father consistently set unrealistic expectations for Franklin, focusing on an ideal rather than self-improvement and growth.

"I was raised in a home that praised the game of basketball. Naturally, we all grew up knowing and playing the game. It was important to us to do well, because our father seemed to transfer our worth according to how we played … this was tough for me because I could never live up to the expectations … I wasn't bad by any means, but I wasn't as good as I 'needed' to be … instead of growing and learning, I beat myself up and got destructive." – Franklin

Additionally, students recognized that many negative experiences in their life had to do with the social judgment around intelligence and ability. Franklin shares how there was a gap between his own hard work, which was hidden to many of his peers, and his external accomplishments that others used to judge his intelligence, such as ACT scores.

> "*I earned a reputation for being smart because I worked really hard at the grades I had. However, people only saw the A's I got as a result. They failed to see the hard work it took to get that. Ergo, they just assumed I was super smart and should do well on the ACT. So I went in with the same expectation they had of me. When my scores came back, I was devastated...I felt like they would see me as 'not smart.*'" -Franklin

In summary, students reacted to gaining a new understanding of the characteristics and implications of a fixed mindset by reflecting on their own past experiences involving themselves and others. Just as negative experiences were reflected on and then interpreted through a fixed mindset lens, positive experiences were described by the students that aligned with the growth mindset. These reactions are reported in the next section.

<u>Past Positive Experiences as an Underlying Growth Mindset</u>

Similar to the intervention responses of reinterpreting past negative experiences as an underlying fixed mindset, students also described positive experiences and reinterpreted them as an underlying growth mindset. Like the negative experiences, positive experiences described personal instances as well as instances resulting from others' influence. Some of the common patterns across past experiences that could be reinterpreted as growth mindset were taking responsibility, putting effort into improving, setting goals, and seeking help. For example, Bret and Don described times when their academic success was directly tied to his own focused effort and help-seeking behaviors.

> "*There were other times in high school when I had daunting tasks to do but approached them with a growth mindset instead. Classes like AP Chem were tough, they even seemed like they might be impossible, but I made myself hit the books to actually learn the material, and in the end I got a 4 on the AP Chem exam."* -Don

> *"I keep stumbling through the homework until I finally reach a point where I have to ask [for] help, and it turns out to not be too hard."* -Bret

Many of these experiences that did lead to productive behavior through a growth mindset were influenced positively by external influences including teachers and coaches. Franklin shared two examples of when adults in his life were able to communicate a growth mindset in both sports

and school. Gert had a new appreciation for his own father's persistence as a source of inspiration to demonstrate growth mindset behavior.

> *"My coach pulled me aside after I had played a bad game. She talked to me and told me things I had never heard before. Things like, 'the game doesn't matter! You did everything you could do. Your worth doesn't depend on how you played. Stop beating yourself up'. This kind of thing amazed me and from then on, she was my support on the court … I worked harder. I played harder. I did my best…"* -Franklin

> *"She got a hold of me. She approached me with the growth mindset and told me to get to work. Study and work hard, but despite it all, the number that comes back doesn't change my worth. From then on, I wasn't as self-conscious about my grades or the ACT results … the growth mindset allowed it not to define me."* -Franklin

> *"[My dad] took eight years of night school to get his bachelor's degree. What this instilled in me at a very young age is to never give up, even if I'd stared failure in the face."* -Gert

In these discussions with the participants, students not only picked up on the characteristics of the growth mindset but were able to reflect on certain points of their life where they recognized their approach to overcome a challenge was aligned with a growth mindset. After reading about growth mindset and using written reflections and in-person discussions to actively reinterpret past experiences through the lens of growth mindset, the strong alignment of positive experiences with growth mindset and negative experiences with fixed mindset solidified students' belief that intelligence is malleable and that a growth mindset is valuable and desirable.

Recognition of Value of Growth Mindset

All of the participants who participated in our intervention favored the idea of a growth mindset. They described that it was the actual reading of the book and discussion with other students that allowed them to fully understand the framework and map it in meaningful ways on to their own lived experiences. Bret and Franklin provided quotes demonstrating how students recognized the value of growth mindsets by trying to practice it, seeing its wide applicability across different aspects of his life, and wanting others to develop a growth mindset too.

> "*This group has made me more actively aware of the mindsets. From time to time I catch myself acting in the fixed mindset, and ask myself 'what would someone in the growth mindset do?' From there, I try to adjust my behavior and determine what put me in a fixed mindset during that situation."* -Bret

"What's amazing is that I can apply these concepts to my academic, social, emotional, mental and physical acts of life." -Franklin

"*[They should] be aware when they are exhibiting fixed mindset behavior. They have to actively try to become growth mindset."* -Bret

In contrast to the negative experiences that were linked to the tendency of others to cast social judgment based solely on external performance, student recognized that growth mindset has the specific potential to allow individuals to have agency over their own decisions and accomplishments rather than a more deterministic view.

"*The gift of growth mindset is to break out of that cycle. To give each individual the power to define themselves, who they are, what they are capable of, and what they will accomplish."* -Franklin

It was the students' commitment to the concept of growth mindset that lead to the second major theme present in their reflections, which was focused on the future.

Major Theme 2: Projecting a Future Utilizing Growth Mindset

Towards the conclusion of the intervention, participants began to shift from just reinterpreting their past experiences through the lens of mindset to projecting how they looked forward to utilizing growth mindset in their future. Many of them began to articulate how learning about growth mindset would allow them to be more aware of how they were interpreting failures and to draw on growth mindset to lead to more positive attitudes and productive behaviors. Students were very positive in what they learned throughout the intervention and understood the broad ways in which growth mindset can be used as a lens for many aspects of a person's life. Table 2 summarizes this theme across student reactions.

Table 2. Summary of second major theme in students' reactions

Theme	Examples
Projecting a Future Utilizing Growth Mindset	Ask for help
	Focus on effort
	Potential pitfalls

The students identified strategies for maintaining a growth mindset such as reaching out for help and to look at where improvements could be made when failure occurred. Students also emphasized the importance of putting effort into work and not just focusing on the outcome. Students emphasized the importance of being aware of the different mindsets, which are useful lenses for interpreting both productive and destructive behavior. When asked how the Mindset theory could be propagated through the community of undergraduate engineering students,

participants conveyed a focus on the importance of environmental influences that helped obtain or keep the growth mindset, especially instructors. Franklin imagined the impact on engineering student retention if students were informed on growth mindset.

> *"I find myself thinking about my mindset and what I hope to accomplish within myself all the time …I'm assuming, but I bet other students in our reading group have had similar experiences and reactions. Now, imagine having hundreds of kids in a class experiencing this same thing – changing their mindsets into that of growth and unlimited potential. I have a feeling we'd see less dropouts in the field of engineering."* - Franklin

Participants also articulated their recognition of the potential pitfalls going forward. This included an expectation that it will be difficult to hold themselves accountable to maintain a growth mindset and that maintaining positive attitudes of intelligence as malleable will be especially difficult during times that are personally difficult.

> "*Making effective plans is hard and holding yourself accountable is even harder. Holding myself accountable will definitely be my largest hurdle in adopting the growth mindset*." - Don

> "*A major barrier will always be to keep a positive/growth mindset at times when things get tough … but hopefully I can manage to grow away from this sort of behavior and learn to keep a consistent growth mindset and think of setbacks as lessons instead of failures*." -Cindy

Bret provided a profound insight related to the challenge of maintaining a growth mindset—it isn't just a simple switch that can be flipped. That sentiment was shared by many participants—growth mindset seems wonderful and enticing, but actually maintaining a growth mindset in a world that consistently communicates fixed mindset messages and rewards requires perpetual attention and effort.

> "*I also learned that changing mindset is not a short, instant process. It is a long, never-ending process that requires constant vigilance to avoid the fixed mindset and move yourself closer and closer to a growth mindset."* -Bret

The intervention concluded with students having gained a thorough understanding of the Mindset theory and the significant role of the beliefs we hold about intelligence. Their deep learning was largely facilitated by the reflection and reinterpretation of past experiences. The participants conveyed a large appreciation for gaining this awareness and felt that the concept was worthy to be propagated throughout the undergraduate experience. The group concluded with a shift towards projecting how this new awareness could be used in the future. Participants

acknowledged how they might experience difficulty utilizing growth mindset in their everyday lives. It was a consensus among the group that growth mindset requires constant reflection and attention—it is not an automatic switch once you are aware and invested in maintaining productive beliefs about intelligence.

Discussion and Implications

This research project is useful for educators interested in promoting productive beliefs about the nature of intelligence. Our study captured the students' perspectives of an in-depth intervention as opposed to a brief introduction, which may be typical of classroom interventions. Findings are meaningful in that they capture the students' perspective to this topic. This project revealed that students develop an understanding of Mindset theory by reinterpreting their past experiences. Several aspects of those past experiences are of particular salience, such as academic failures negatively impacting self-worth, challenges being demotivating, and the prevalence of social judgment on academic achievement.

Awareness Translated Primarily to Recognition of Fixed and Growth Characteristics

Across both major themes that resonated with students throughout the growth mindset intervention, a strong focus was on identifying characteristics of fixed or growth mindset in themselves and others. It can be seen throughout the data that as the students read more of Dweck's book, they were able to recognize moments in their pasts where they, or others, exhibited behaviors that could be explained through a lens of either fixed or growth mindsets. They often recalled moments of difficulty or triumph in their life and could link it to an underlying (and subconscious) belief about intelligence as either fixed or malleable. By being able to recognize these traits, students could relate with both fixed and growth mindsets and provide a better understanding on how to work towards maintaining a growth mindset. Students who work towards a growth mindset possess the belief that their intelligence is not stagnant which motivates them to continue learning [21-24].

For most students, reading the Mindset book was their first exposure to identifying these mindsets. Learning about the characteristics of the mindsets enabled them to draw connections with themselves and people they know and reinterpret their own personal experiences in a new and meaningful way. The responses from students throughout the focus group supports the idea that in order for fixed and growth mindsets to be personified, students need initial exposure to them to understand what prompts one mindset over the other. While this awareness was welcomed by the participants, other research has shown that just providing individuals with an awareness of a hidden belief/phenomenon does not necessarily help and can even be harmful [32]. Additionally, educators that are aware of mindsets but are not familiar with how to foster them may label a student as a fixed when they do not understand something instead of addressing how to help them [33].

A significant finding was seeing the number of student responses that wrote about situations of fixed mindset but were then able to project how they could apply growth mindset. When students did project to the future, they often had hopes and set goals for how they could apply growth mindset. In a study that focused on foreign language learners and their beliefs about natural talent, researchers found that goal setting was tied to a person's mindset [34]. More specifically, they found that learners who felt they could achieve an ultimate level of learning, set that level as their personal goal while learners who did not think they could achieve an ultimate level of learning, set lower goals. The idea that goals were set based on what the person believed they were capable of, resonates with the students who set their goal of achieving growth mindset whenever they would encounter challenges in their future. This displayed the influence of the mindset intervention in that they were applying the lessons from the Dweck book to their own experiences and reflecting on how to draw on the growth mindset the next time they find themselves in the fixed mindset. However, it was beyond the scope of our study to track these students and understand the longer-term effects of this intervention on their own beliefs and behavior.

The implication of this finding is the understanding that there is a stark difference between learning about growth mindset and shifting our fundamental beliefs about effort. Especially because fixed mindset beliefs are so pervasive in culture and often subconscious in ourselves, changing those beliefs is not well understood. Therefore, it is important for educators wanting to teach growth mindset to differentiate between raising awareness and building a community of practice around productive beliefs.

Beliefs about Intelligence are Dynamic and Contextual

Many students came to realize that growth mindset is not permanent. However, it is not enough to only recognize that people can experience fixed and growth mindsets; people need to understand what supports growth or triggers fixed mindsets [35]. Mercer and Ryan [34] believe that by having educators encourage growth mindset to students, students would be equipped with the skills needed to handle failure while also increasing their effort towards their work. But educators cannot simply tell students about mindsets. Teachers have a role to provide students with the tools needed to approach mindsets [36]. In line with Dweck and colleagues [36], the students that participated in this intervention, did recognize the importance of having the tools necessary to, in a given situation, shift their thinking from that of a fixed to that of a growth mindset. Even shortly after being introduced to growth mindset, the students articulated their understanding of the potential of growth mindset to motivate themselves and accomplish difficult tasks. According to Dweck [19], the first step to gaining awareness of the framework is to embrace the fixed mindset. In their discussions, the same students who became aware of times they experienced fixed mindset, were also projecting to the future with hopes of moving towards a growth mindset when facing obstacles. Dweck [19] mentions that by embracing the fixed

mindset, a person can work towards understanding how it is triggered. However, not all people who experience fixed mindset are equipped with these skills. Therefore, it is important to consider how our educational settings can foster and reward a growth mindset.

Limitations

One limitation of this study was the participation of self-selected students. It is likely that these students are the type who go above and beyond, and therefore may be more receptive to the idea of growth mindset. Additionally, the findings were limited due to our use of the prompts from the text. The intervention was designed to be a focus group about the book, *Mindset: The New Psychology of Success* by Carol Dweck. While the published prompts were effective in facilitating the discussion, they also may have limited the open-endedness of the responses from the participating students and therefore our findings.

Conclusions and Future Work

This research has contributed to our understanding of beliefs about intelligence in undergraduate engineering education by identifying emergent themes with respect to how first-year engineering student react to an in-depth intervention about growth mindset. This study revealed that the major reaction to an in-depth growth mindset intervention was reflecting on past experiences and re-interpreting them through a Mindset lens, followed by projection of the possibilities for growth mindset to help individuals in the future. Students embraced the potential of growth mindset to lead to more productive reactions and behaviors both in their academic and personal lives. This indicates a need for additional work to understand concrete strategies for individuals who have learned about growth mindset to begin to implement such productive practices into their everyday habits. Future work should also capture the ways in which the culture(s) of undergraduate engineering education can be shifted to develop and sustain growth mindset.

Appendix: Focus Group Prompts Used to Solicit Student Reflections, Adopted from [19]

Chapters 1 and 2

1.1. Think about someone you know who is steeped in the fixed mindset. Think about how they're always trying to prove themselves and how they're super sensitive about being wrong or making mistakes. Did you ever wonder why they were this way? (Are you this way?) Now you can begin to understand why.

1.2. Think about someone you know who is skilled in the growth mindset--someone who understands that important qualities can be cultivated. Think about the ways they confront obstacles. Think about the things they do to stretch themselves. What are some ways you might like to change or stretch yourself?

2.1. Is there something in your past that you think measured you? A test score? A dishonest or callous action? Being fired from a job? Being rejected? Focus on that thing. Fell all the emotions that go with it. Now put it in a growth-mindset perspective. Look honestly at your role in it, but understand it doesn't define your intelligence or personality. What did you learn from that experience? How can you use it as a basis for growth?

2.2. How do you act when you feel depressed? Do you work harder at things in your life or do you let them go. Next time you feel low, put yourself in a growth mindset--think about learning, challenge, confronting obstacles. Think about effort as a positive, constructive force, not as a big drag. How might you use this strategy in school, and what might be the benefits?

2.3. Is there something you've always wanted to do but were afraid you weren't good at? Describe your plan to do it.

Chapter 3

3.1. Think about your hero. Do you think of this person as someone with extraordinary abilities who achieved with little effort? Now go find out the truth. Find out the tremendous effort that went into their accomplishment--describe how this impacts your perception of them.

3.2. Are there situations where you get stupid--where you disengage your intelligence? Next time you're in on of those situations, how can you get into the growth mindset? What will happen if you think about learning and improvement, not judgment?

3.3. More than half of our society belongs to a negatively stereotype group. First you have all the women, and then you have all the other groups who are not supposed to be good at something or other. How can you give them the gift of growth mindset?

Chapters 4 and 5

4.1. Are there sports you always assumed you're bad at? Well, maybe you are, but then maybe you aren't. Describe your experience with the sport and what might've lead to your current beliefs about your abilities.

4.2. "Character" is an important concept in the sports world, and it comes out of a growth mindset. Think about times you've needed to reach deep down inside in difficult sports matches. Think about the growth-mindset champions from this chapter and how they do it. What could you do next time to make sure you're in a growth mindset in the pinch?

5.1. Are you in a fixed-mindset or growth-mindset workplace (or school)? Do you feel people are just judging you or are they helping you develop? Maybe you could try making it a more growth-mindset place, starting with yourself. Are there ways you could be less defensive about your mistakes? Could you profit more from the feedback you get? Are there ways you can create more learning experiences for yourself?

5.2. How do you act toward others in your workplace (or school)? Are you a fixed-mindset teammate, focused on yourself more than on others' well-being? Do you ever reaffirm your status by demeaning others? Do you every try to hold back high-performing students because they threaten you?

Chapters 6 and 7

6.1. After a rejection, do you feel judged, bitter, and vengeful? Or do you feel hurt, but hopeful of forgiving, learning and moving on? Think of the worst rejection you ever had. Get in touch with all the feelings, and see if you can view it from a growth mindset. What did you learn from it? Did it teach you something about what you want and don't want in your life? Did it teach you some positive things that were useful in later relationships?

6.2. Are you shy? Growth mindset can help you from messing up your social interactions. Next time you're venturing into a social situations, how can you work to improve your social skills? What are some strategies you can use to learn and practice navigating social situations?

7.1. How do you praise? Remember that praising intelligence or talent, tempting as it is, sends a fixed-mindset message. It makes their confidence and motivation more fragile. What are ways you can provide feedback that focuses on strategies, effort, or choices?

7.2. Do you think of slower students as kids who will never be able to learn well? Do they think of themselves as permanently dumb? Instead, recognize that they may be missing learning strategies they need to be successful. Why might that be the case, and what could you do to help them?

Chapter 8

8.1. What are your major takeaways from participating in this group?

8.2. What do you think will be major barriers from you consistently applying growth mindset in your life and your learning from here on out?

8.3. What are some ideas for keeping this conversation going after our final meeting? How can we hold each other accountable to think about our intelligence and abilities in productive ways?

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