Beliefs Matter: The Interplay and Influence of Engineering Faculty Beliefs on Instructional Practices

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Introduction

For many years, there have been calls from government agencies and professional organizations for changes in engineering, science, and math education to better support students and to prepare them for a changing world [1], [2]. Answering these calls, engineering education scholars are examining various avenues to bring about change within engineering education to improve student outcomes. Researchers have focused on numerous areas of interest, including instructional practices and faculty beliefs, which is the focus of this paper. Studies about instructional practices [3] - [6] have revealed that the classroom behaviors of instructors and the implicit and explicit messages they send to students can impact students' beliefs [8] - [11]. Faculty beliefs/mindsets is another area of interest for researchers, where studies have revealed that faculty beliefs can affect student outcomes [12], [13]. For example, research has established that faculty who seemed to believe that intelligence (or other abilities) is malleable and can be improved through practice and training (analogous to having a growth mindset) were perceived as more motivating, had higher student achievement in their courses (by URM and white students), and were perceived more positively by the students [13] - [15].

Although the two areas—faculty instructional practices and mindset beliefs directly impact student outcomes, the interplay between the two factors has yet to be explored. In other words, the question-- how faculty beliefs affect the choice of their instructional practices in the classroom is yet to be fully explored. There is some evidence to suggest that growth and fixed mindsets impact instructional decisions. For example, a study by Aragón, Eddy, and Graham [16] shows that instructors with fixed mindsets about intelligence were less likely to be persuaded to use active learning techniques in their classes. In addition, Richardson, Bledsoe, and Cortez [17] established a relationship between instructor mindset and the teaching behaviors of faculty members who teach undergraduate courses in STEM disciplines. However, there is limited research on engineering faculty's mindsets and their impact on instructional practices. This **work-in-progress** study addresses this gap by examining the beliefs/mindsets of engineering faculty and their impact on instructional practices.

Theoretical Framework and Study Concept

Dweck's growth-fixed mindset framework

Dweck's growth-fixed mindset framework [18] is frequently deployed to examine individuals' beliefs about self-abilities in different domains. In the framework, a growth mindset is defined as a belief that intelligence (or other abilities) is malleable and can be improved through practice and training. In contrast, a fixed mindset is a belief that intelligence is fixed and cannot be changed with practice or training. For example, an individual may have a growth mindset about math abilities, thinking that their math skills can improve with practice, but may have a fixed mindset about art, believing that they were deficient in artistic ability, which is perceived to be immutable and unchangeable, even with practice. Beliefs about capabilities such as creativity

[19], empathy [20], math [11], computer science [21], and Engineering [22] have been examined using Dweck's framework.

In this study, we consider the influence of faculty beliefs in three specific domains (teaching ability, engineering ability, and entrepreneurial ability) to examine the relationship between faculty beliefs and instructional practices. The dashed box in Figure 1 displays the factors included in this study (student outcomes depicted outside of the box are beyond the scope of this study). We also collected data on beliefs about general intelligence to determine if growth/fixed mindset has a global influence on instructional practices.

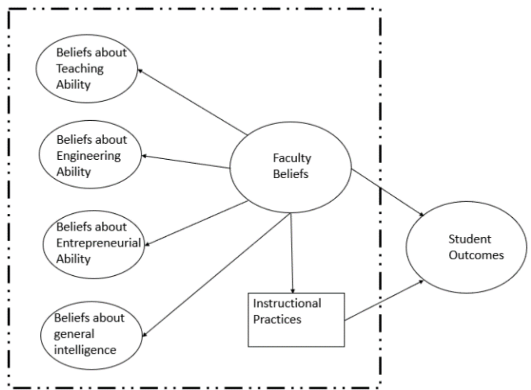

Figure 1: Concept diagram for the exploratory study. The dashed box includes factors explored in this study.

Instructional Practices

With the goal of innovating teaching and learning in engineering, researchers have examined the various instructional practices used by instructors and established that although some techniques are proven to be effective teaching and learning tools, there is a reluctance on the part of instructors to incorporate them into the classrooms. Furthermore, there is evidence in the literature to show that educators struggled to decide how to effectively integrate research-based practices into their teaching, revealing a direct link between instructor beliefs and teaching practices [23] – [25]. Thus, it would be fruitful to probe more deeply into the relationship between faculty beliefs in different domains and the adoption/non-adoption of research-based instructional practices.

Faculty Beliefs in Different Domains

In this study, we consider the faculty beliefs from three specific domains (teaching ability, engineering ability, and entrepreneurial ability) and examine beliefs about general intelligence for triangulation to explore whether general intelligence might globally influence the beliefs in the other three domains.

<u>Teaching ability</u>*:* Several researchers have examined the teaching ability of instructors through the lens of growth and fixed mindset aiming to encourage faculty to develop a growth mindset. For example, Frondozo et al. [26] tested a hypothesis that similar to the growth and fixed mindsets associated with intelligence, there would be growth and fixed mindsets related to

teaching ability. Their study revealed that a growth mindset about one's teaching ability positively predicted greater work engagement mediated by enjoyment. Other studies have also related beliefs about teaching ability to faculty outcomes [16], [27], [28].

Engineering Ability*:* There is a common narrative within engineering and popular culture that people who enter engineering are naturally oriented toward the "engineering way of thinking." Many high school students choose engineering as a major because "they are good at math and science" [29]. These messages promote a message of fixed mindset regarding engineering ability. Although instructor beliefs have been explored in other domains, such as physics [10] and math [11], no studies have examined engineering faculty beliefs about the malleability of engineering ability and how these beliefs impact instructional practices. The current study thus examines beliefs about engineering ability as a factor affecting the instructional practices of engineering faculty.

Entrepreneurial Abilities*:* Entrepreneurship education has made headways into engineering programs as it is believed to equip engineers with skills that could lead to job generation and sustainable design. Acknowledging the benefits of an entrepreneurial mindset, researchers are examining the influence of entrepreneurship education on different facets of engineering [7], [31]. The mixed research findings about the links between the two disciplines support considering faculty beliefs about entrepreneurial abilities as a factor impacting instructional practices.

General Intelligence: Several studies have been conducted on faculty beliefs about general intelligence and its influence on student outcomes [13], [16]. It has been established that an instructor's growth or fixed mindsets about intelligence, in general, are known to influence student outcomes positively or negatively. Therefore, faculty beliefs about General Intelligence are included in this study to compare with the beliefs about the malleability of abilities within other domains.

Using Dweck's framework to gain deeper insights into engineering faculty's beliefs about abilities in different domains--1) engineering ability, 2) entrepreneurial-related abilities, 3) teaching ability, and 4) general intelligence and their subsequent influence on instructional practices, we explore the following research questions:

- How do beliefs about the nature of abilities in different domains vary across engineering faculty members?
- How do faculty beliefs about the nature of abilities across different domains impact instructional practices?

This work-in-progress paper describes a battery of scales (Table 1) designed to assess the correlations between faculty beliefs across different domains and instructional practices in service to answering these questions.

Methods

Data for the study were collected by deploying the survey to engineering faculty members at a large university in the Mid-Atlantic region of the United States. Preliminary validity and reliability evidence was gathered for the scales in the Summer and Fall of 2022.

Participants

Survey response data were collected from faculty members who had taught engineering courses within the past three years or were currently teaching by asking them to complete the electronic version of the survey. Seventy-two complete survey responses were received.

Battery of Scales

The battery of scales was assembled to answer the two research questions. The survey specifically aimed to collect information on faculty beliefs about the malleability of teaching, engineering, and entrepreneurial abilities and their influence on instructional practices. The survey comprised three preexisting scales designed to measure the mindsets about engineering ability, entrepreneurial ability, and instructional practices and a new teaching ability scale created by adapting/modifying items from other scales based on Dweck's general intelligence growth/fixed mindset framework. See Table 1 for references and example items.

Table 1: Battery of Scales

Scale	Ref.	Example Item
Teaching Beliefs Scale	[19][22][26]	"Anyone can learn to be an effective teacher."
Engineering Beliefs Scale	[22]	"Ability to be an engineer can be acquired if one works at it."
Entrepreneurship Beliefs Scale	[31]	"The ability needed to be an entrepreneur can be learned."
Instructional Practices Scale	[33]	"Think of the recent times you taught an engineering course; approximately how often did you do the following in your class?" "Discuss learning outcomes or goals."

Data collection procedures

The survey was administered in the fall of 2022 using Qualtrics [34]. Engineering faculty members were invited to participate in the study. Eighty-four of the 514 invited faculty responded, which yielded a total response rate of roughly 16%.

Preliminary Findings

The preliminary findings of this exploratory study are summarized below. For this work-in-progress paper, we provide the means, the standard deviations, and the correlation matrix for subscale scores. We also share a preliminary finding of a t-test comparing gender differences in the Beliefs about Engineering Ability.

Descriptive statistics and correlation matrix

The means, standard deviations, and correlations for each of the Faculty Beliefs subscales – Beliefs about Teaching Ability (BTeaAb), Beliefs about Engineering Ability (BEngAb), Beliefs about Entrepreneurial Ability (BEntAb), Beliefs about Intelligence(BInt) are shown in Table 1.

We observed that the Beliefs about Teaching Ability correlated with Beliefs about Engineering Ability (r = .55, p < .001) and Beliefs about Entrepreneurial Ability (r = .56, p < .001). The correlations were moderate in strength, positive in direction, and statistically significant. In addition, Beliefs about Engineering Ability correlated with Beliefs about Entrepreneurial Ability (r = .63, p < .001) and Beliefs about Intelligence (r = .36, p < .001). The correlations were moderate to low in strength, positive in direction, and statistically significant. Correlations between the different abilities and the Instructional Practices scale are currently being examined.

Table 1: Descriptive Statistics and intercorrelations for Faculty Beliefs and Instructional Practices instrument subscales

	M	SD	BTeaAb	BEngAb	BEntAb	BInt
TeaGM	4.1	.57	--			
EngGM	4.0	.70	**.547****	--		
EntGM	3.7	.48	**.557****	**.626****	--	
IntGM	3.4	.99	.190	**.363****	.189	--

Beliefs about Engineering Ability: Comparisons by gender:

Preliminary findings of an independent sample t-test comparing faculty Beliefs about Engineering Ability across genders shows that women faculty members (N=28) measured higher (M=4.23, SD =.51) than men faculty members (N=38), (M=3.82, SD = .70), t(63.9) = 2.6, *p* = .01.

Discussion and next steps:

The preliminary results indicate that the means for all the subscales in the sample population measure greater than 3.0, the mid-point of the respective five-point scales. This suggests that most participants believed in the malleability of abilities in the different domains. Furthermore, the difference in the means for the beliefs about Engineering ability along gender lines indicates that women faculty members' belief that anyone can become an engineer is stronger than men. The qualitative phase of the study will probe deeper to gain insights into faculty members' perceptions of belief formations.

The correlations in Table 1 show that the beliefs in the three domains are partially correlated and, contrary to expectation, are not correlated with the malleability of general intelligence. This point will also be investigated further during a detailed analysis and the qualitative phases to understand why certain correlations exist while others do not. We will ask faculty members to elaborate on the interconnectedness of their beliefs in different domains. The relation between beliefs and instructional practices will be explored further to examine whether the results from prior studies [16] will corroborate our findings about the correlation between a growth mindset (general intelligence) and instructional practices.

The study findings will help assess faculty mindsets in different domains and may support the design of targeted faculty development interventions.

Acknowledgments

This project was funded by the Mentorship 360 Project at Arizona State University as part of the Kern Entrepreneurship Education Network (KEEN).

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