Engineering Faculty's Mindset and The Impact on Instructional Practices

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***Abstract* – This innovative practice work-in-progress presents instructional practice through the lens of faculty mindset. The importance of investigating novel and effective approaches to recruit, retain, and graduate students in undergraduate engineering programs from a more diverse range of cultural backgrounds is becoming a focus for researchers in the field of engineering education. A key area of investigation of retention strategies is promoting change in instructional practices used in the engineering classroom [1]. Moreover, many factors influence engineering faculty's instructional practices and in turn affect retention and matriculation of students in engineering. Effective change strategies of engineering faculty instructional practice are tied to the belief of the individual faculty [2], [3]. While substantial research studies address the strong connection between faculty's instructional practices and the effects on student achievement, less research focuses on how faculty's mindset drives instructional practices and this study aims to fill this gap.**

Dweck's mindset theory guided this exploratory study to evaluate the relationship between engineering faculty's mindset and their instructional practice. The study was conducted at a Carnegie classified Doctoral/Professional University within a College of Engineering. The measurement scales of the survey included the following: 1) mindset of engineering faculty [4] and 2) instructional practice [5]. Each scale included Likert type questions with items rated on a 6-point scale that ranged from strongly agree (1) to strongly disagree (6). The survey instrument concluded with open-ended responses to indicate the participant's willingness to be interviewed and demographic information.

Specifically, in this paper we examined the relationship between engineering faculty's mindset and instructional practice. Based on the small study, data trends emerged across the mindset spectrum of faculty from a fixed to a growth mindset and how this influenced their instructional design choices. This study establishes ground work for best practices that other institutions can adopt to improve engineering student retention and success through the lens of the mindset of engineering faculty.

Keywords – faculty attitudes; instructional methods; diversity; inclusion

I. INTRODUCTION

There is a growing national concern on the importance of educating engineers for the 21st century. Paired with it are declining retention rates within undergraduate engineering programs. Engineering faculty play a key role in educating the engineers for the 21st century and supporting engineering identity to support their retention in the field. The role of faculty is particularly important to the engineering identity development of students from marginalized groups who often report ubiquitous forms of inequity and prejudicial experiences across school context [6]-[13]. Although engineering education research explores various approaches to explain and enhance faculty-student interaction it provides limited studies that detail how to support the next generation of engineers from marginalized groups who still often struggle with a sense of authenticity, belonging, and identity [14], [15] within the social culture of engineering.

Moreover, the social culture of engineering leads to varying types of experiences that can diminish engineering identity development and self-perceptions, which is linked to lack of motivation and poor academic performance. For example, African American students have a different academic experience than their White counterparts in terms of faculty interactions [16]. Also, negative self-perceptions are prevalent for marginalized students in STEM despite showing the technical aptitude to both enter and complete rigorous engineering and other STEM undergraduate education programs [17], [18]. While researchers have examined the self-perception and mindset of students [19]-[25] and how these can be performance-inhibiting, to our knowledge, researchers have not yet explored how engineering faculty's mindset is linked to constructs that have been shown to affect student self-perception and outcomes.

This research establishes groundwork for a future study of how engineering student mindset are adopted from faculty mindset and are potentially related to student choices to continue in engineering and habits of success. By characterizing the role of engineering faculty and student mindset, we can identify moderating factors that administrators and faculty can work to create tools and training to reshape the beliefs that might have a negative effect on student success and engagement.

II. PUROPOSE AND RESEARCH QUESTIONS

The purpose of this work in progress is to lay the foundation for the impact of faculty mindset's impact on instructional practice. Although much engineering education research has focused on students, we are expanding the scope of this scholarship to empirically describe faculty contributions to the teaching and learning relationship. Understanding this relationship or correlation can also identify potential barriers, such as faculty beliefs, to the success of students from a variety of backgrounds and with a variety of abilities. In response, we pose the following research questions: **(1) What is the mindset (fixed or growth) of faculty within the College of Engineering? (2) Is there a relationship between faculty mindset and instructional practice?**

III. THEORETICAL FRAMEWORKS

The literature on mindset identifies a variety of student characteristics or behaviors that impact student achievement and success. It shows that students who believe that intelligence or math and science ability is simply a fixed trait (a fixed mindset) are at a significant disadvantage compared to students who believe that their abilities can be developed (a growth mindset) [4]. What is investigated to a lesser extent is how the mindset of the faculty influences their instructional practices and how these constructs support student success or diverse students. We expect that faculty mindset predicts instructional practice over time and that interventions that change faculty mindset can boost student retention and reduce achievement discrepancies for marginalized populations.

Because this work is exploratory, multiple theoretical frameworks informed our analysis, each selected based on our research questions and in response to patterns we noticed in reviewing and discussing our research questions. This includes Dweck Mindset [4] and the Postsecondary Instructional Practices Survey (PIPS) [5]. Combined, these frameworks provides our research team with consistent terminology to use when discussing mindset, ability, and institutional practice.

The impetus of this study is to understand how faculty mindset is related to creating learning environments to enhance or diminish engineering identity development. The mindset theory proposed by Carol S. Dweck [26] defined "mindset" as implicit theories that individuals hold regarding the nature of intelligent behavior. Individuals attributing intelligence to static traits hold a "fixed" theory of intelligence (i.e., a fixed mindset) and individuals attributing intelligence to learning, effort, training, and practice hold a "growth" theory of intelligence (i.e., a growth mindset). "Mindset" is not a permanent status, but changes and can evolve with time, context, and experience. Based on Dweck's definition of "mindset", we operationalize faculty mindset as the faculty beliefs regarding the nature of intelligent behavior of themselves and their students including the degree in which that they attribute intelligence of students as a "fixed" trait or a "growth" trait.

IV. THE SURVEY INSTRUMENT

An operationalized definition of mindset based on the work of Carol S. Dweck [4] and instructional practice as defined by the National Research Council [5] are used as constructs in our study design.

Using the two measurement scales: Dweck Mindset Instrument (DMI) [4] and the Postsecondary Instructional Practices Survey (PIPS) [5].

A. Dweck Mindset Instrument

Is intelligence fixed or can it be developed? The Dweck Mindset Instrument (DMI) measures the degree in which one believes that intellectual abilities are basically fixed or that intellectual abilities are cultivated and developed through application and instruction. The DMI is used to assess how faculty view intelligence.

The DMI comprises 16 separate items, which faculty ranked their level of agreement or disagreement with the items from "strongly agree" (1) to "strongly disagree" (6). The items are written in such a way that faculty reveal their thoughts and feelings about whether they believe talent and intelligence are characteristics that are malleable or unable to change.

The DMI contains both fixed item statements and incremental item statements. The scores from the incremental items are "reversed" so that strongly disagreeing with an entity item is similar to strongly agreeing with an incremental item. The fixed item statements on the survey consist of statements 1, 2, 4, 6, 9, 10, 12, and 14. These statements focus on both intelligence and talent being factors that are fixed. The incremental items on the survey are item numbers 3, 5, 7, 8, 11, 13, 15, and 16. There are four fixed items and four incremental items focusing on intelligence, and there are four fixed items and four incremental items focusing on talent development. The scores selected by faculty for the incremental statements, those statements that portray intelligence and talent as something that can be changed, are reversed (1 becomes a 6, 2 becomes a 5, 3 becomes a 4, 4 becomes a 3, 5 becomes a 2, and 6 becomes a 1). These scores are averaged with the items that portray intelligence and talent as being factors that are fixed and unable to change.

Items 1 – 8 are statements regarding intelligence and items 9 – 16 are statements regarding talent. The intelligence statements and talent statement scores are averaged individually as two separate groups since they are two separate characteristics.

B. Postsecondary Instructional Practices Survey

The Postsecondary Instructional Practices Survey (PIPS) is designed to measure the instructional practices of postsecondary instructors from any discipline. The PIPS is used to measure the instructional practices of the faculty of the College of Engineering. The PIPS comprises 24 instructional practice statements and nine demographics questions. The faculty ranked from "strongly agree" (6) to "strongly disagree (1) on how descriptive each statement was of their teaching. Where "strongly agree" corresponds to "very descriptive of my teaching" and "strongly disagree" corresponds to "not at all descriptive of my teaching". This scale is used to align with the DMI scale used.

The PIPS contains two factors: student-centered practice and instructor-centered practice, which is the 2F scoring option. Where instructor-centered is defined as the practices in which the instructor is the sole or primary actor, including how the instructor present information, design of summative assessments, and grading polices. Student-centered practices are defined as practices in which the students are the sole or key factor(s), including interactions among students in class, students' active and constructive engagement with course content, and formative assessment practices. The student-centered practice items are 2, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 18, 19, and 20. The instructor-centered practice items are 1, 3, 5, 11, 17, 21, 22, 23, and 24. Scores are calculated based on how faculty members ranked student-center practice items and instructor-centered practice items. Scores from each centered practice are summed for each faculty member and divided by the maximum sum for each category. For example, the content delivery score for the student-center practice items are calculated by summing actual scores from 2, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 18, 19, and 20. Because each PIPS item is rated as high as six (very descriptive of my teaching), and there are fifteen items in this factor, the maximum possible sum for student-centered practice is 90. By dividing the actual sum for the student-centered practice values by the maximum possible sum and multiplying by 100 generates a factor score between 0 and 100.

The survey instrument concludes with open-ended responses to indicate the participant's willingness to be interviewed and demographic information. Demographics included gender, race, tenure status, academic rank, and principal field of teaching. The participants are asked to provide an email address, mailing address, and phone number if they would consider an individual interview as part of the primary data collection for the second phase of the study. The survey completion time typically lasts between 15-25 minutes and the research team will report summative data to maintain anonymity of the participants and only use identifying information to solicit further participation in the research study.

V. DATA COLLECTION

The quantitative data for this study came from a survey conducted during the fall of 2019. The survey was distributed to all faculty members in a Carnegie classified doctoral/professional university with a College of Engineering that contains the departments of Mechanical Engineering, Civil Engineering, Electrical Engineering, and Chemical Engineering. We emailed all faculty in the College of Engineering with an invitation to participate in the online survey.

Demographics of Study Population

A total of nine survey participants completed the survey for the first round of survey distribution. Eight male (89%) and one female (11%) participated in the survey. Of the participants, three were from Civil Engineering, three were from Mechanical Engineering, and three identified as "other" engineering departments. Three held rank at the associate level, two at the assistant level, one at the instructor level, one at the lecturer, and one "other" level.

VI. RESULTS

RQ1. What is the mindset (fixed or growth) of faculty within the college of engineering?

The first research question, based on Dweck's Theory of Intelligence research [4], focused on making a distinction between individuals who hold an entity versus incremental theory of intelligence. The average mindset score of each faculty was calculated by averaging their response across the entire instrument. Participants were assigned "a mindset category based upon their average score: 0.0–2.0 = fixed mindset; 2.1–4.0 = mixed mindset; 4.1–6.0 = growth mindset. While previous literature typically used fixed and growth mindsets categories, a mixed mindset category was used in previous studies to classify individuals with an average mindset score at the center of the scale [28, 29]." Faculty who received an average score between 4.1 and 6.0 were counted as holding an incremental (growth mindset) theory and view intelligence and talent development as characteristics that are malleable and able to change. Faculty who received an average score between 2.1 and 4.0 were counted as holding a mixed mindset where they did not have a clear theory of whether intelligence is either a malleable or fixed trait. Faculty who received an average score between 0.0 and 2.0 were counted as holding an entity theory (fixed mindset) and view intelligence and talent development as characteristics that are not malleable and able to change.

Approximately 33% of faculty were labeled as "mixed" in their view of intelligence, meaning that they do not have a clear theory of whether intelligence is either a malleable or fixed trait. Most faculty were labeled as "growth" in their view of intelligence, meaning that they believe that most basic abilities can be developed through dedication and hard work.

Table 1. Percentage of Faculty Identified in Each Theorist Category of the DMI

Intelligence Group	Number of Faculty	Percentage (%)
Fixed (Entity)	0	0.0%
Mixed	3	33.3%
Growth (Incremental)	6	66.7%
Total	9	100.0%

RQ2. Is there a relationship between faculty mindset and instructional practice?

The second research question considered if a relationship exists between faculty responses to the PIPS to their assigned mindset designation. To answer this research question, the average student-centered practice and instructor-centered practice scores of each faculty were calculated from survey data and correlated with the results of the mindset categories.

PIPS factor scores ranged from 0 to 100 with 100 representing "very descriptive of my teaching", 75 representing "mostly descriptive of my teaching, 50 representing "somewhat descriptive of my teaching", 25 representing "minimally descriptive of my teaching" and 0 representing "not all descriptive of my teaching" [5]. PIPS 2F (student-centered practice and instructor-centered practice) scores were represented on a frequency-based bar graph with scores from an individual faculty with a growth mindset and an individual faculty with a mixed mindset (Figure 1).

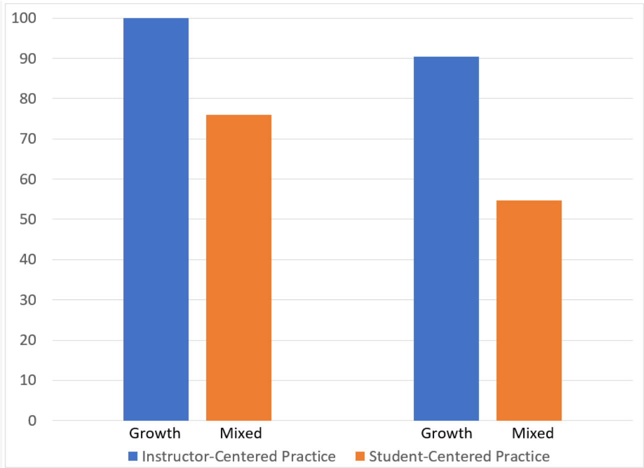

Figure 1. PIPS 2F scores for an individual faculty with a growth mindset and an individual faculty with a mixed mindset

Average weighted sums of PIPS 2F scores were calculated for faculty with mixed mindsets and faculty with growth mindsets. Table 2 shows that the average Student-Centered Practice score for faculty with a growth mindset was 73.02 and the average Student-Centered Practice score for faculty with a mixed mindset was 69.05. This is a 5.595 difference. It also shows that faculty with a growth mindset had an average Instructor-Centered Practice score of 89.51 and faculty with a mixed mindset had an average of 80.25. This is a 10.91% difference. Faculty with growth mindsets had an average score on the PIPS 2F factor score of student-centered practice and instructor-centered practice that was **higher** than faculty labelled as a mixed mindset (Table 2). This highlights the significant differences in average PIPS 2F scores of faculty with growth mindset vs. faculty with mixed mindset.

Table 2. Average PIPS 2F Scores by Faculty Mindset

	Growth Mindset (Incremental)	Mixed Mindset	% difference (growth vs. mixed) scores
Student-Centered Practice	73.02	69.05	5.59
Instructor-Centered Practice	89.51	80.25	10.91

The Chi-Square Test of Independence was run to determine the association between engineering faculty mindset and instructional practice.

The null hypothesis was:

H_0: engineering faculty mindset was independent of their instructional practice.

The alternative hypothesis was:

H_1: engineering faculty mindset was NOT independent of their instructional practice or H_0 was false.

Based on the results, we can state the following:

No association was found between engineering mindset and instructor-centered practice ($X^2(7)> = 9$, $p = 0.253$).

No associate was found between engineering mindset and student-centered practice ($X^2(8)> = 9$, $p = 0.342$).

Since the p-value is greater than the chosen significance level ($\alpha = 0.05$) for both instructor-centered practice and student-centered practice, it was concluded there was not enough evidence to suggest an association between engineering faculty mindset and instructional practice. We do not reject the null hypothesis.

Spearman's correlation coefficient was used to measure the strength of engineering faculty mindset to individual PIPS items.

The null hypothesis was:

H_0: engineering faculty mindset was independent of their individual instructional practice techniques.

The alternative hypothesis was:

H_1: engineering faculty mindset was NOT independent of their individual instructional practice techniques or H_0 was false.

There was a very strong, positive monotonic correlation between engineering faculty mindset and PIPS item 7: I have students use a variety of means (models, drawings, graphs, symbols, simulations, etc.) to demonstrate knowledge ($r_s = 0.867$, $n = 9$, $p < 0.02$).

There was a strong, positive monotonic correlation between engineering faculty mindset and PIPS item 17: I give students frequent assignments worth a small portion of their grade ($r_s = 0.676$, $n = 9$, $p < 0.046$).

Therefore, we have some evidence to believe that engineering faculty mindset is NOT independent of their individual instructional practice techniques. We concluded that a more detailed analysis on individual instructional practice techniques and how it related to faculty mindset should be used to identify a range of traditional and research based teaching practices that are affected by faculty mindset. It is important for researchers, faculty, institutions, and policy makers to have a valid and reliable method to determine how faculty mindset affects instructional practices.

VI. FUTURE WORK

The larger study will establish groundwork for best practices that other institutions and disciplines can adopt to improve engineering student retention and success through the lens of the mindset of engineering faculty and instructional practice. By characterizing the role of engineering faculty mindset and identifying moderating factors, administrators and faculty can work to create tools and training to reshape the beliefs that might have a negative effect on student success and engagement. Future work includes expanding to larger colleges of engineering, interviewing participants to explain results, and refining the survey instrument, and developing a national instrument to asses engineering faculty mindset across the country.

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