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PERCEPTIONS OF ENGINEERING FACULTY ON EDUCATIONAL INNOVATION AT HISPANIC-SERVING INSTITUTIONS

Meagan R. Kendall,[1,*] Alexandra Coso Strong,[2] Gemma Henderson,[3] & Ines Basalo[3]

[1]*The University of Texas at El Paso, 500 West University Ave, El Paso, Texas 79968, USA*

[2]*Florida International University, 11200 SW 8th St., Miami, Florida 33199, USA*

[3]*University of Miami, 1320 S. Dixie Highway, Coral Gables, Florida 33146, USA*

*Address all correspondence to: Meagan R. Kendall, Department of Engineering Education and Leadership, The University of Texas at El Paso, 500 West University Ave., El Paso, TX 79968; Tel.: +915-747-7829, E-mail: mvaughan@utep.edu

As the educator of nearly one-third of all Latinx engineering graduates in the United States, Hispanic-Serving Institutions (HSIs) are at the forefront of innovating engineering curriculum for Latinx students. In many cases, the driving force behind these innovations in engineering is the faculty. This study aims to identify the assets and challenges that engineering faculty at HSIs perceive impact their ability to engage in educational innovation and, ultimately, create inclusive and learner-centered educational experiences. Specifically, the thematic analysis of workshop artifacts enabled the researchers to examine the perspectives of 24 engineering educators from two- and four-year colleges across the Southwestern and Southeastern United States who attended one of two National Science Foundation–sponsored workshops. The artifact analysis illustrates how engineering educators at HSIs recognized particular assets to leverage when innovating within their courses and departments, both from within and outside of their institutions. At the same time, these educators also acknowledged barriers to innovation from various sources, including personal, interpersonal, and administrative. Recognizing that faculty experiences can vary based on their position's responsibilities, this study also begins to explore the differences in perception of educational innovation across instructional and tenure-line faculty. These differences across faculty types suggest an opportunity to bring different perspectives and skillsets to educational innovation collaborations that include faculty from diverse backgrounds and roles. Overall, this study provides a foundation for future research on factors impacting faculty engagement with inclusive and learner-centered pedagogy at institutions seeking to serve Latinx and other racially and ethnically diverse students.

KEY WORDS: *design thinking, institutional transformation, Hispanic-Serving Institutions, faculty development, instructional role, engineering education, curriculum design*

1. INTRODUCTION AND BACKGROUND

In learner-centered teaching, we ask educators to deepen their understanding of their students, develop empathy for the diverse individuals within their classroom, and ultimately design their courses and activities to recognize and support students' backgrounds, strengths, interests, and goals (Garcia, 2019; Paris, 2012). This study uses design thinking tools to do the same for engineering faculty at Hispanic-Serving Institutions (HSIs), a largely unexplored population. In particular, we examine the perceptions of engineering faculty members at HSIs as they described their engagement in educational innovation toward inclusive and learner-centered pedagogy. The results of this study elevate the voices of these faculty as they navigate existing resources and articulate challenges to educational innovation at their institutions.

HSIs are defined as two- or four-year nonprofit institutions that enroll 25% or more full-time Latinx* students (National Academies of Sciences, Engineering, and Medicine, 2018). The number of HSIs has grown steadily since the designation was created, from 189 in 1994 to 539 in 2019, and these HSIs enroll over 67% of all Latinx undergraduate students (Excelencia in Education, 2020; Hispanic Association of Colleges and Universities, 2018; National Academies of Sciences, Engineering, and Medicine, 2018). The institutions that comprise this group of minority-serving institutions represent a diverse set of institutional contexts with varying institutional missions, percentages of enrolled Latinx students, and populations of Latinx cultures (Núñez and Elizondo, 2015). Their transitions to receiving an HSI designation are also diverse, as many began as primarily White institutions (PWIs) and now have over 25% Latinx enrollment. While it is possible for an HSI to also be a PWI, if we assume PWI means 50% of enrolled students identify as White, PWI can be used synonymously with non-minority-serving institutions (MSI).

Overall, HSIs are uniquely equipped to enrich the outcomes of Latinx and other traditionally marginalized students through admission and retention initiatives, student-centered support programs, and inclusive curricula (Ballysingh et al., 2017; Garcia, 2017; Garcia and Okhidoi, 2015; Marin, 2019). In comparison to a non-HSI setting, HSIs often provide a place for students to reflect upon and develop their identities, with opportunities to join organizations and engage in coursework that connects to their cultural identity (Garcia, 2018). Research on inclusive and learner-centered curricula at HSIs illustrates how instructors incorporate diverse perspectives in course readings, activities, and assessments (Garcia and Okhidoi, 2015), use multiple types of assessments that provide students different mediums through which to express their knowledge (Núñez et al., 2010), or encourage students to explore connections between their personal biographies and what they are learning in the course (Kendall et al., 2019c; Montoya et al., 2015; Núñez et al., 2010). The outcomes of these teaching approaches can be seen, for example, in explorations of Latinx student engagement. While Latinx students attending either an HSI or PWIs are equally likely to graduate (Flores and Park, 2015), attending an HSI is reported to positively impact Latinx student engagement, especially in first-year students and seniors (Fosnacht and Nailos, 2016).

While this and other research has demonstrated the value of HSIs for Latinx and other students broadly, there is limited research on inclusive and learner-centered practices within engineering specifically (Hasbún and Coso Strong, 2020). Engineering has

*Throughout this paper, we will use the term Latinx to describe individuals who identify as having Latin American origins. This term is inclusive of all gender identities and those who identify as Hispanic and/or Chicano (Camacho and Lord, 2013; Simmons and Lord, 2019).

historically been an exclusionary field for Latinx students, women, and those whose race or ethnicity is non-White (Camacho and Lord, 2013; Simmons and Lord, 2019). For instance, while the number of engineering bachelor's degrees earned by Latinx students increased by 79% from 2011 to 2016, Latinx students only represent 11% of all students earning these degrees (APLU, 2018). Of the top 25 institutions conferring engineering bachelor's degrees to Latinx students, 60% of these students in 2009 did so at an HSI (Santiago, 2012), and as of 2016, six of the top ten institutions awarding these degrees were HSIs (APLU, 2018). Overall, HSIs represent only 9% of the 533 colleges and universities with undergraduate engineering programs, yet they play a significant role in granting engineering bachelor's degrees to Latinx students (APLU, 2018; Hasbún and Coso Strong, 2020). While scholars have outlined programmatic and structural changes to broaden participation and improve the recruitment and retention of underrepresented students in engineering (Lee and Matusovich, 2016; Simmons and Lord, 2019), the work has predominantly focused on PWIs.

To explore engineering at HSIs, researchers must recognize the institutional diversity of HSIs, and as such, that engineering education research at PWIs may not appropriately describe student and faculty experiences at HSIs. HSIs are striving to serve traditionally underserved populations and, at the same time, are institutions that are racially minoritized (Garcia, 2019). In other words, these institutions are examined, ranked, compared, and classified based on performance indicators grounded in Whiteness (Garcia, 2019; Garcia et al., 2019). To illustrate this point, many HSIs are less-selective, broad-access institutions, and while these institutions may be providing culturally responsive and enhancing educational experiences for their students, the reality is that their outcomes do not resemble those of more selective institutions (Garcia, 2019; Garcia et al., 2019; Núñez et al., 2016). Yet, we lack research that explores HSIs as HSIs and continue to compare and classify based on these racialized performance indicators. With this understanding of HSIs compounded by the limited research on engineering at HSIs, there is a need for research that provides a foundation for understanding the landscape of student and faculty experiences in engineering and existing educational innovation within the curriculum and courses' distinct context.

The current educational innovation and change literature in engineering education is limited to frameworks and perspectives centered on experiences and innovations at PWIs. More broadly, research on factors impacting faculty engagement with inclusive and learner-centered pedagogy is also limited to institutions where Latinx and other racially and ethnically diverse students are the minority (Núñez et al., 2010, 2015). Engineering education research has highlighted barriers for faculty engagement in educational innovation generally, such as faculty perceptions of departmental culture around teaching (Finelli et al., 2014; Finelli and Froyd, 2019; Lund and Stains, 2015; Piskadlo, 2016) and faculty beliefs about teaching (Henderson et al., 2011). However, there is a need to investigate the experiences and perceptions of engineering faculty at HSIs and the factors influencing their engagement in educational innovation (Besterfield-Sacre et al., 2014).

1.1 The Role of Engineering Faculty in Shaping Educational Experiences

Faculty play a critical role in shaping educational experiences that promote student learning. Faculty members are mentors and advisors (Dennehy and Dasgupta, 2017), and their interest in students' success is linked to students' sense of belonging (Maestas et al., 2007). They directly impact how the learning environment affects student motivation (Ryan and Deci, 2000), and they model inclusive behaviors, or lack thereof (Linder et al., 2015). For example, Canning et al. (2019) examined how the faculty beliefs about student intelligence relate to the underperformance and lower motivation of traditionally marginalized students in their STEM classes. However, at HSIs, helping individual faculty become culturally responsive can be challenging, especially given the drastic demographic differences between faculty and students at these institutions. While over 25% of students in STEM disciplines at HSIs are Latinx, Latinx faculty comprise only 14.4% of faculty in science and engineering (Excelencia in Education, 2017).

Within engineering, researchers have also articulated the critical role of engineering faculty in shaping the experiences of all students (Camacho and Lord, 2013; Dika and Martin, 2018; Henderson et al., 2011; National Academies of Sciences, Engineering, and Medicine, 2018; Simmons and Lord, 2019). These and other scholars have encouraged faculty use of inclusive and learner-centered instructional practices to create learning environments that promote students' intrinsic motivation and enhance their learning (Ryan and Deci, 2000; Simmons and Lord, 2019). Inclusive and learner-centered course design seeks to elevate the student voice and recognize their backgrounds, strengths, interests, and goals. In our previous explorations of HSI engineering faculty, for example, participants noted characteristics that they perceived as both assets and challenges for their students, namely, (1) cultural diversity, (2) bilingualism, (3) comfort working in groups/teams, (4) commuter, (5) family responsibilities, (6) time management, (7) work experience, and (8) motivation (Kendall et al., 2019a).

While a faculty member's role in creating inclusive and learner-centered classroom experiences is clear, our prior work demonstrated critical differences in faculty experiences within engineering programs at HSIs (Coso Strong et al., 2019). In particular, our previous work highlighted differences between tenure-line faculty and instructional faculty. Here we define instructional faculty as those who are primarily evaluated on their teaching and, at many universities, are not eligible for tenure (e.g., full-time professors of practice, professors of instruction, or lecturers). Instructional faculty expressed a desire to develop and implement learner-centered, culturally responsive instructional designs but lacked the support given to their tenure-line counterparts (Coso Strong et al., 2019). In other studies, these faculty also report higher use of active learning strategies than their tenure-line peers (Watson et al., 2019) and see themselves as professional teachers, not aspiring academics (Fitzmorris et al., 2016). These instructional faculty often fill teaching roles in lower-level courses or provide industry experience in upper-level courses (Fitzmorris et al., 2016; Thedwall, 2008). Historically, instructional faculty have been under-resourced and afforded limited representation in institutional governance, hampering their engagement in educational innovation (Eagan Jr. et al., 2018; Kezar, 2013).

Further, instructional faculty, while articulating many of the same descriptors for their students as tenure-line faculty, more readily associated these descriptors with challenges their students face than assets (Kendall et al., 2019a), again highlighting the unique perspectives afforded different faculty roles. As a result, there is a need to identify the extent to which there are differences in experiences and perspectives across faculty types related to their engagement with educational innovation within engineering.

As such, the purpose of this research is to articulate the perceptions of engineering faculty at HSIs who self-selected to participate in a two-day faculty development workshop to reimagine engineering education at their institution. The workshop was framed to enable the faculty participants to explore their own experiences and their teaching. The results of this qualitative study of workshop artifacts seek to identify the assets and challenges that engineering faculty members at HSIs perceive impact their ability to engage in curriculum innovation and, ultimately, create learning experiences that are inclusive and learner centered. In particular, this study adds to our understanding of those faculty at HSIs who, because they self-select to participate in this professional development opportunity, may be more motivated to engage in education innovation. By making explicit how these faculty perceive the assets and challenges at their institutions, we can begin to articulate existing resources and needs within the engineering educational environments at HSIs and develop approaches to amplify and support faculty efforts toward inclusive and learner-centered pedagogy.

1.2 Researchers' Positionality and Approach

This current study is part of a larger research project intended to understand and gather multiple, diverse perspectives from engineering educators in response to the Dear Colleague Letter (DCL) published by the National Science Foundation (NSF) (National Science Foundation, 2017). This DCL and the related projects were among several steps NSF took to solicit community input to identify the most critical challenges and opportunities regarding undergraduate STEM education at HSIs and subsequently frame the research agenda for the HSI Program established in 2018 (NSF EHR Subcommittee, 2017a).

In response to this DCL and based on this understanding of the literature, we took an asset-based approach and leveraged the empathy-building tools of design thinking to learn from and with HSI engineering educators. We took the resulting four positions within our research design: (1) We approached educational *change* discussions, a term commonly used in the literature, from an educational *innovation* perspective. Educational change can suggest a deficit-based approach, articulating an assumption that the educators need to correct or change what they are doing (Paris, 2012; Samuelson and Litzler, 2016). Given the limited literature on engineering at HSIs, we chose not to make that assumption (National Academies of Sciences, Engineering, and Medicine, 2018). Further, we differentiate between curricular and educational innovation. (2) We grounded our work in design thinking principles and tools. This framework and how we used it as the theoretical foundation for the study are described later. In particular, we focused on the empathy-building tenets of design thinking to take on an open-minded learner posture to build a deep understanding of participants' experiences (Walther et al., 2017). (3) Our explorations of faculty perceptions were designed to not overtly suggest that faculty discuss how they support their Latinx students only. Recognizing the diversity of students at HSIs and among HSIs (Núñez et al., 2016), we explored faculty perceptions of educational innovation without limiting their discussions to a subset of their student population (e.g., Latinx students or a particular Spanish-speaking culture). (4) Our research team also intentionally includes engineering faculty, engineering education researchers, and faculty developers from Latinx and other minoritized populations across two HSIs and one emerging HSI. (5) Our ultimate goal for this project is to promote inclusive and learner-centered practices within engineering.

2. DESIGN THINKING AND BUILDING EMPATHY

To better understand the perspectives of engineering faculty implementing educational innovations within their HSI context, the concept of design thinking was adopted as the guiding framework for the design of the study and the structure and content of the workshop series. Design thinking is a well-established concept within engineering practice, research, and education (Dym et al., 2005; Mann and Daly, 2009; Razzouk and Shute, 2012). Widely known as a collection of human-centered principles and models (Baggeroer et al., 2018; IDEO, 2015), design thinking engages stakeholders to create innovative outcomes to ill-defined problems (Johansson-Sköldberg et al., 2013; Zenke, 2014). Design thinking systemically starts by building empathy with stakeholders to inform the design of interventions that will enact positive change (Henriksen et al., 2020; Kouprie and Visser, 2009; Walther et al., 2017, 2020). In their model of empathy for engineering, Walther et al. describe empathy as a skill, a practice orientation, and a professional way of being that involves being open-minded, becoming comfortable around different perspectives, and avoiding judgment to inform an individual's perception of their world (Panke, 2019; Walther et al., 2017).

Design thinking was therefore applied as an exploratory, iterative, and practice-based process (Cross, 2011; IDEO, 2015) to (1) inform the research design of this study, (2) design the curriculum for the workshop series, and (3) introduce participants to a set of principles to leverage within their teaching practice. Within the context of engineering educational research, building empathy helps researchers establish a baseline to understand participants' needs, values, cultures, and characteristics within their unique context. As we describe later, the research team implemented a multiday workshop series to serve as our method for empathy building and data collection of participants' perspectives and experiences with educational design efforts. This workshop setting enabled individual and collective sharing and meaning-making by the researchers and engineering educators through various design thinking activities (e.g., pre- and postsession reflective assessments, in-person discussions, collaborative workshop activities).

In our prior work, we describe how design thinking principles were leveraged to help engineering faculty build empathy with their students (Kendall et al., 2019a) and recommend a strategic engineering education research agenda for HSIs (Henderson et al., 2019). In this paper, we focus on the empathy-building phase of our larger project and seek to understand the experiences and perceptions of engineering faculty at HSIs as they engage in educational innovation by leveraging design thinking principles to build empathy, explore, interpret, and discuss the complex systems of HSIs and their engineering education programs.

3. EDUCATIONAL INNOVATION WORKSHOP OVERVIEW

Rather than rely on research methods, like individual and focus group interviews, that risk separating the participant from the phenomena of interest by asking them to reflect on past experience or project into the future, we instead sought an approach that would allow us to listen and observe while participants reflected in and on action. This workshop series was our selected approach, since it allowed us to build empathy with engineering educators at HSIs while actively engaging in a design thinking–based educational innovation effort. These workshops were an invitation to engineering educators at HSIs to participate in a professional development opportunity that would provide innovation tools. At the same time, we collectively examined the state of engineering education at HSIs.

As such, a series of two, two-day regionally focused workshops were held during the spring of 2018. Thirty-six engineering educators from 13 HSIs across the southern United States attended one of the Rethinking Engineering Education at HSIs workshops (Kendall et al., 2018b). Overall, workshop attendees included a diverse set of engineering educators, including tenure-line (i.e., tenured and tenure-track faculty), instructional faculty (i.e., full-time professors of practice, professors of instruction, and lecturers), part-time lecturers, administrators, and staff with instructional responsibilities. The researchers provided each participant with a stipend for their participation.

As previously discussed, the workshop structure and content were grounded in design thinking principles and asked participants to complete a series of activities that encouraged them to (1) empathize with and explore the unique characteristics and needs of their student population and institutional stakeholders, (2) brainstorm opportunities for educational innovation at their institution worth pursuing, (3) prototype their preferred intervention and identify the necessary assets and resources, and (4) develop a plan for implementation and testing. At the heart of inclusive and learner-centered approaches to education is the educators' ability to build empathy with and understand their students and improve their students' learning experience and outcomes. To facilitate *exploration* of their students' and other stakeholders' needs, participants completed a preworkshop assignment where they were asked to engage with a diverse set of institutional stakeholders and summarize their findings in a brief online survey. This activity sought to encourage faculty to obtain a broad understanding of stakeholders' perspectives and needs at their institution and act as institutional representatives. During the workshop, participants shared the results of their stakeholder engagement activities to explore students' unique needs and characteristics across HSIs. These faculty perspectives on student characteristics at HSIs are documented here (Kendall et al., 2019a).

In keeping with the shared goal of inclusive and learner-centered approaches to education and to facilitate *brainstorming* around possible opportunities for innovation, attendees were introduced to two broad, pedagogy-agnostic educational theories. Intrinsic motivation and students as empowered agents were introduced as lenses to examine their students' educational experiences. Intrinsic motivation was introduced as a lens for participants to reflect on their courses, their role as educators, and their impact on students' motivation and academic performance (Ryan and Deci, 2000). Through an intrinsic motivation lens, participants explored the extent to which students control their own learning and relate to engineering topics, their community, and institution. This exploration was complemented by activities that engaged participants in examining their students' agency or the extent to which students felt they could take intentional actions toward their learning and professional goals (Benedict et al., 2020; Goller and Harteis, 2014; Newstetter et al., 2010, 2004). Together the activities and examples shared throughout the workshop sought to equip faculty with ideas for empowering and developing learners who embrace ambiguity, learn from their experiences, construct methods to approach problems, and take intentional action toward learning and professional goals. Based on participants' collective understanding of their students and guided by intrinsic motivation and student agency principles, participants brainstormed potential opportunities for innovation at their institution. Participants selected a stakeholder and corresponding challenge or opportunity they wanted to address. Participants were encouraged to brainstorm various lofty goals and not eliminate ideas because they seemed impossible at the moment.

Following the initial idea generation exercise, participants were encouraged to select and *prototype* their preferred solution and explore barriers and opportunities impacting their implementation efforts. This prototyping exercise and the identified assets and challenges documented on the associate worksheet are the focus of this paper and are described in more detail in the Methods section. At the conclusion of the workshop, participants developed action plans so they could *implement and test* their ideas upon returning to their institution.

Throughout the workshop, multiple worksheets were used to facilitate and document the various activities and discussions. Each participant retained their workshop artifacts, but a copy was made for research purposes. A follow-up survey, distributed to participants during the fall of 2018 to determine the impact of the workshop series on participants, indicated implementation efforts following the workshop, particularly among instructional faculty (Coso Strong et al., 2019). In addition to this current study, analysis of these artifacts has brought to light a variety of future research opportunities, documented here (Henderson et al., 2019; Kendall et al., 2019b).

4. METHODS

This qualitative study leverages HSI engineering educators' responses to a series of design thinking activities during the professional development workshop described previously (Creswell and Poth, 2017). By asking participants, who self-selected to participate, to design an educational innovation for their course, department, or institution and reflect on what it would take to enact that innovation, this study seeks to understand engineering faculty perspectives on educational innovation at HSIs by answering two research questions:

RQ1: What assets and challenges do engineering faculty at HSIs perceive impact their ability to engage in educational innovation?

RQ2: What are the differences in engineering faculty at HSIs perspectives based on faculty roles (e.g., tenure-line and instructional faculty)?

4.1 Participants

Of the 36 total workshop attendees, 29 completed the educational innovation design activity that is the focus of this study. Of those who consented to participate in the study and completed the design activity, only the faculty with full-time teaching roles were included in this analysis (n = 24; Table 1). Therefore, instructional developers, part-time lecturers, staff, and administrators were excluded from the analysis. Full-time instructional faculty made up 58% (n = 14) and tenure-line faculty made up 42% (n = 10) of the participants included in this study. Compared with the overall workshop population, instructional faculty made up a larger proportion of this study group (58% vs. 44%), and tenure-line faculty made up approximately the same (42% vs. 44%). On average, the current study participants had six years of experience in their current position at an HSI and 15 years of experience teaching engineering overall.

Of the participants included in the current study, 33% identified as women and 25% identified as Latinx. These rates differ from the whole workshop population, as more women (33% vs. 25% overall) and fewer individuals who identified as Latinx (25% vs. 39% overall) participated in this activity. Though options to self-describe or select transgender, genderqueer, or gender nonconforming were also made available, only one

TABLE 1: Participant demographics

Participant Group	Total	% Women	% Latinx	Avg. Years in Current Position (Min–Max)	Avg. Years Teaching Engineering (Min–Max)
Tenure-line faculty	10	30%	10%	7.25 (1–27)	20.4 (3.5–49)
Instructional faculty	14	36%	36%	5.1 (1–14)	10.8 (1–20)*
Design activity participants	24	33%	25%	6.0 (1–27)	15.0 (1–49)
Workshop participants**	36	25%	39%	6.5 (0.25–27)	12.9 (1–49)

*One participant did not report.

**Includes design activity participants.

participant identified as being transgender. Options to report race were made available to participants separate from ethnicity. Given the focus of the study, only participants' identification of a Hispanic or Latinx ethnicity was analyzed.

Representation also varied across faculty roles. More women and Latinx participants had instructional faculty positions, similar to the general workshop population and patterns identified in the literature (Excelencia in Education, 2017).

Because of the diversity of institutions that qualify as HSIs and the lack of contextual richness offered when using classification systems that emphasize research productivity, four-year graduation rates, and other White normative standards, we instead use the institutional classification system developed by Núñez et al. (2016) for HSIs to describe the institutions represented at the workshop series. Each institution's data were obtained from the Integrated Postsecondary Education Data System (IPEDS) database for fall 2017 and used to classify the institutions represented at the workshop series (IES: NCES, 2020; Table 2). Of the six HSI categories identified by Núñez et al. (2016), two were not represented in this workshop series, i.e., Puerto Rican Institutions and Health Science Schools. Thirteen HSIs from Arizona, New Mexico, Texas, and Florida were represented at the workshop series.

TABLE 2: Institutions represented at the workshop series classified using Núñez et al. system for HSIs (2016)

HSI Classification	Num.	Carnegie Classification	Admissions Rate Avg. (Min–Max)	Total Students Avg. (Min–Max)	% Hispanic Avg. (Min–Max)
Urban Enclave Community Colleges	2	Baccalaureate/ Associate's Colleges: Associate's Dominant	Open/100%	48,378 (40,754–56,001)	53% (37%–70%)
Big Systems Four-Years	9	Doctoral Universities: 1 Moderate, 3 Higher, 5 Highest research activity; 7 Pub., 2 Priv.	68% (36%–100%)	28,670 (8674–56,718)	46% (23%–80%)
Rural Dispersed Community Colleges	1	Baccalaureate/ Associate's Colleges: Associate's Dominant	Open/100%	5564	49%
Small Communities Four-Years	1	Master's Colleges and Universities: Small Programs	22%	2009	26%

4.2 Data Collection

This paper focuses on participants' responses to a design activity that prompted them to generate innovative ideas to enhance student learning at their institution. The handout for this portion of the design activity (Fig. 1) was based on a curriculum development framework that helps ensure completeness and alignment of their educational innovation efforts, GAPA. Based on identifying a stakeholder group and a corresponding educational design challenge, GAPA links the Goals of an educational innovation with the Activities used to achieve the stated goals, the Products that stakeholders generate as a result of completing the activities, and the Assessment tools and techniques used to determine whether the goal has been achieved (Stolk and Martello, 2018).

Before completing a poster-sized handout of this framework (Kendall et al., 2018b), participants were given an overview of how the workshop facilitators applied the framework at their institutions. Participants were encouraged to complete the numbered sections of their GAPA handout (dark gray portions in Fig. 1) and then hang them on the wall for a modified gallery walk (McConnell et al., 2017). The gallery walk provided an opportunity for workshop facilitators and other participants to give feedback on the preliminary designs. Participants then refined their final GAPA handout and brainstormed the resources, assets, and challenges they perceived related to implementing their plan.

Prompts on the worksheet asked participants about supports and barriers related to the following:

- **Current academic curriculum:** What supports can be provided by the current curricula within and outside of engineering? What barriers do you foresee engaging with the current curriculum or trying to change it?

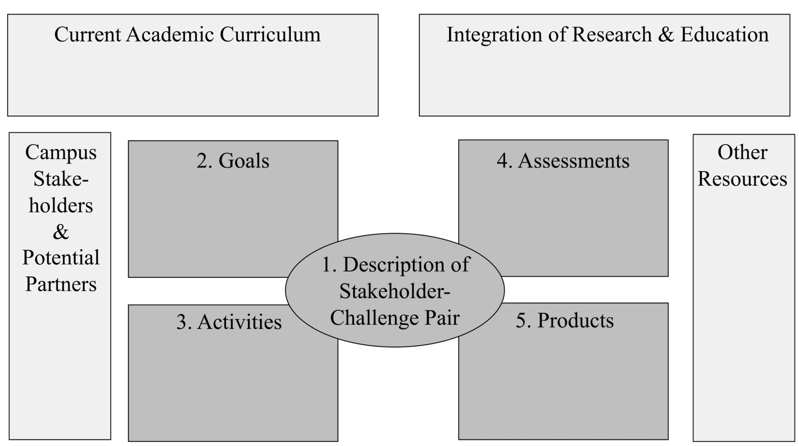

FIG. 1: Simplified layout of the GAPA handout with prompts removed (based on the results of Kendall et al., 2018b)

- **Campus stakeholders and potential partners:** What supports can students, faculty, and staff at your campus AS WELL AS industry partners, or other academic institutions provide? What barriers do you foresee to using or obtaining these resources?
- **Integration of research and education:** What supports can research infrastructure (e.g., funding, labs) or outcomes (e.g., scholarship of teaching and learning or technical content that can be taught) on your campus provide? What barriers do you foresee to using or obtaining these resources?
- **Other resources:** What supports can physical infrastructure, funding, or other resources provide? What barriers do you foresee to using or obtaining these resources?

These prompts were based on topic areas and prompts used during a nationwide survey of HSIs facilitated by the Building Capacity at Hispanic Serving Institutions Subcommittee of the NSF Directorate for Education and Human Resources (NSF EHR Subcommittee, 2017a,b). This survey and the corresponding listening sessions were part of a suite of needs assessment activities that informed the design of the NSF HSI program launched in 2018 (National Science Foundation, 2017).

4.3 Data Analysis

To explore the beliefs of engineering faculty at HSIs about assets and challenges that impact their ability to engage in educational innovation (RQ1), participant responses were analyzed using an inductive process to identify emerging themes (Borrego et al., 2009; Creswell and Poth, 2017; Miles and Huberman, 1994). An inductive approach is consistent with our design thinking framework as it preserves the study's exploratory nature. We deidentified and transcribed responses from participants on the GAPA handout for analysis. During the thematic analysis, we first grouped participant responses based on the type of resource or support being identified into one of five categories: (1) engineering curriculum enhancement, (2) academic partnerships, (3) integration of research and education, (4) student and faculty support, and (5) physical infrastructure and other resources. These categories were based on the original prompts (Fig. 1) and refined during analysis to better represent participants' responses, e.g., *other resources* was expanded into separate categories of *student and faculty support* and *physical infrastructure and other resources*. The research team completed three rounds of thematic analysis. In the first round, a single researcher transcribed responses and identified an initial list of refined category titles and emergent themes within each category's responses. During the second round, a second investigator coded each participant's response based on the themes, refining the definition of themes as needed. Both researchers completed a final round of analysis to reach a consensus on refined category titles, themes, and coding of responses.

Because the design activity built on prior brainstorming handouts and activities, when appropriate, we referenced prior artifacts from individual participants to fill in missing data or provide a richer context for vague responses. Though prompts were provided on the worksheet to encourage completeness of participants' responses, responses were not required, and, therefore, some prompts were left unanswered. Further, responses were analyzed regardless of which section of the handout participants recorded them (e.g., if a participant listed a resource related to *student support* under *campus stakeholders*, it was still classified as student support or both, as appropriate). In addition, we aggregated results across the participants' self-described faculty roles to identify differences across instructor type (RQ2). We then reviewed the aggregate results to ensure consistent interpretation of category and theme wording. To further confirm the interpretation of theme wording and categorization of subthemes, member checking was completed with five participants from each workshop during a follow-up workshop at the 2018 ASEE Annual Conference.

4.4 Protection of Vulnerable Populations

All workshop participants were informed of the institutional review board–approved nature of the project before consenting to participate. Attendees who did not wish to be included in the study were still welcomed to participate, but the research team did not review their workshop artifacts for study purposes. Attendees were not informed as to who was or was not participating in the study. Responses were deidentified before storage and analysis.

5. RESULTS AND DISCUSSION

Through the analysis of workshop artifacts, the engineering faculty participants at these HSI-focused workshops identified a diverse set of assets and challenges impacting their educational innovation engagement at their institutions. However, before presenting the thematic analysis results, we open with a discussion of the design challenges that the participants chose to address to provide additional context. Then, to explore the implications of this thematic analysis and answer our research questions, each category's assets and challenges are summarized and compared across faculty types to examine unique trends and points of tension.

Based on the original prompts, the thematic analysis of assets and challenges is organized into five categories. First, the *engineering curriculum enhancement* category captures participants' perceptions of how individual courses and curricula targeted at engineering students are designed or could be redesigned to enhance student success within their institutional context. The *academic partnerships* category describes the perceived need for and the intricacies of working with individuals and organizations to achieve their desired educational outcomes. These partnerships include those that participants currently have or need to develop within or outside their institution. In seeking educational change, the *integration of research and education* theme reflects participants' sense of the influence both technical and educational research has on and in educational innovation, either as a source for evidence-based pedagogies or real-world examples for use in courses. The category of *student and faculty support* encompasses a wide variety of existing and desired resources that support student success, either directly (e.g., tutoring and other academic services) or indirectly (e.g., through the direct support of faculty in their efforts to provide meaningful learning experiences for students), and that are seen as necessary in achieving the participant's innovation. Finally, *physical infrastructure and other resources* describes the physical, personnel, monetary, and other practical resources that participants deemed necessary to complete their project.

5.1 Opportunities Identified by Participants for Educational Innovation

To better situate these findings in context, we first summarize the types of educational innovation opportunities participants pursued in the workshop activity. Using the design thinking approach presented in the workshop, participants leveraged a series of preworkshop reflection exercises to conduct a needs assessment of stakeholders at their institution (e.g., undergraduate or graduate students, other faculty, staff). In self-selected groups of four, participants shared common characteristics, assets, and challenges their students face across and within engineering programs at HSIs based on their individual needs assessments and began identifying potential interventions. Participants selected a single challenge or opportunity to pursue from the list of brainstormed challenges. Participants identified the stakeholder most impacted by their chosen challenge, creating a stakeholder-challenge pairing for further reflection. The stakeholder categories identified by the research team during analysis are included in Table 3 alongside the corresponding direct quote from each participant describing their educational design challenge. Because of the instructions given to participants, all stakeholders identified were from engineering programs at HSIs. Participants were encouraged to consider specific characteristics they had observed about the stakeholder group rather than focusing on a particular demographic characteristic, e.g., Latinx. However, the conversation was mainly around the attributes of Latinx students.

As these challenges were generated iteratively and collaboratively, it was not unexpected that multiple participants would pursue a similar challenge; however, they often focused on a different stakeholder group. For example, a Florida team initially focused on a shared challenge of "textbook selection utilization." However, when they selected and began working on their individual stakeholder-challenge pair, the stakeholder group descriptions varied from "Students in senior design," "Students, most of them work, they have financial restrictions, cultural roadblocks," "Students, software, small class, material science," and "Students (electronics)." This range in stakeholders linked to a shared challenge reflects the participants' recognition that, while multiple institutions may share a similar challenge, the students' characteristics and their institutional context vary, and consequently, so do the proposed interventions. The detailed descriptions of student stakeholders generated by participants in this study are documented further in Kendall et al. (2019a).

TABLE 3: Stakeholder-challenge pairs selected by each participant for the educational innovation design activity. Participants' faculty role are noted. The stakeholder categories identified by the research team during analysis are included with the corresponding direct quote from each participant describing their educational design challenge

Stakeholder Category (Researcher-Identified)	Corresponding Design Challenge (Participant-Identified Direct Quotes)	Faculty Role
Students		
Students (all)	Job readiness of our students as design engineers	Instructional
	Motivate students to truly learn course material	Tenure-line
	[Build students' sense of belonging]*	Tenure-line
Students where English is their second language	[Improve] English language skills [e.g., understand the nuances of the English language]	Instructional
Students in a target course (e.g., senior design)	Textbook selection utilization	Instructional
	[Improve student textbook "reading" and utilization]	Tenure-line
Lower-division students	Freshmen lose motivation in sophomore year	Instructional
	Create "mountain top" advising system	Tenure-line
	Students self-awareness of their problem-solving skills	Tenure-line
	Not all faculty know how to teach*	Instructional
Upper-division students	Improving weak math skills	Instructional
	The final project in Biomedical […] and making it work	Tenure-line
Upper-division students from various backgrounds	Engagement in learning process	Tenure-line
Upper-division students in a target course	Reading comprehension	Instructional
	Best way to encourage students to work in groups	Instructional

TABLE 3: (*continued*)

Stakeholder Category (Researcher-Identified)	**Corresponding Design Challenge (Participant-Identified Direct Quotes)**	**Faculty Role**
Students with significant external responsibilities and limited support (e.g., commuters, working full/part-time, weak academic preparation)	Textbook usage by students	Instructional
	Improving student performance on tests/homework/reports	Instructional
	Time Management	Instructional
	Time Management	Instructional
	[Helping students feel confident/assured talking with faculty and students]	Tenure-line
	Breaking down barriers separating students and faculty	Tenure-line
Faculty		
Faculty (all)	Communication among faculty	Tenure-line
Inexperienced educators	Not all faculty know how to teach*	Instructional
	Faculty buy-in	Instructional
Administrators		
Chairperson/dean	[Build students' sense of belonging]*	Tenure-line

*This participant identified two stakeholders for the same challenge.
[ ] Denotes the authors' interpretation of the participant's missing response based on the participant's other responses on the same worksheet.

5.2 Engineering Curriculum Enhancement

When asked to examine their design challenge from the perspective of engineering curriculum enhancement, participants described their educational innovation from the standpoint of innovations to existing engineering curriculum and the implications behind doing so in the context of their institution. From the descriptions of the assets and challenges participants provided for their selected opportunity, three themes emerged: (1) *pedagogical approaches and activities that support learning*, (2) perceived *resources that support curriculum innovation*, and (3) *factors that impact student learning* that should be considered in curricular innovation. Table 4 summarizes each themes' codes and whether they were assets, challenges (in **bold**), or both (in ***bold italics***). These codes are organized based on faculty role in rows and by theme in columns.

Encouraged by workshop facilitators, participants focused on improving *how* courses are taught rather than *what* is taught when describing their solution's curricular elements. Participants pointed to extracurricular activities, guest lecturers, research engagement, online course format, and introductory courses as pedagogical approaches and activities to improve student learning on their campus. All of these approaches are

TABLE 4: Comparison across faculty roles of assets and challenges identified by participants related to engineering curriculum enhancement across three themes

Engineering Curriculum Innovation Themes			
Faculty Role	**Pedagogical Approaches and Activities that Support Learning**	**Factors Impacting Student Learning**	**Resources that Support Curriculum Innovation**
Instructional faculty	+ Guest lecturers + Lab work + Online course format + Extracurricular activities + Research experience	– **Class size**	+ Labs for research + Partnerships with industry + Existing technical content + Current curriculum provides benchmark/ foundation – **Proper technology** – **Limited time** ***+/– Interdisciplinary collaborations***
Both		– **Amount of content in curriculum**	
Tenure-line faculty	+ Introductory courses + Lab tours	+ Faculty/student interactions	

Note: All codes were identified with a plus icon (+) as assets. Bold items with a minus (–) were identified as challenges, and bold italic were identified as both assets and challenges.

supported in the literature for use in engineering at PWIs (Borrego et al., 2010; Finelli and Froyd, 2019), but studies on their impact in engineering at HSIs are limited. Interestingly, none of the faculty focused on problem- or project-based learning (Prince and Felder, 2006, 2007) explicitly. However, workshop attendees mentioned problem- and project-based learning during other activities and used them as examples in other workshop materials. Literature has documented the resistance to project-based learning due to faculty's perception that it requires extensive overhauls in course designs, students will resist these approaches, higher faculty engagement throughout the course, or, as in the case of project-based learning, additional space, materials, and supplies (Finelli et al., 2014; Henderson and Dancy, 2007; Kober, 2015).

The concern about limited time to invest in educational innovation is echoed throughout the results. For example, participants recognized the value of interacting with students on improving learning outcomes; however, participants pointed out that these interactions take time. For one instructional faculty member in particular, a repeated barrier they perceived related to obtaining the various support and resources needed for their proposed innovation was "Time constraints for quality management. […] Time demands. […] Time management based on faculty workload."

Concerning resources, participants emphasized the value of the existing content, acknowledging how the "current curriculum provides benchmark/foundation." However, in pointing out the value of the existing courses and curriculum, participants also pointed to existing struggles in managing the amount of content in programs. The only challenge recognized by participants from both faculty groups was the concern about the amount of content in the curricula. As one participant observed, they have a "very full curriculum and adding another course is hard." However, why this is the case is unclear from the current data, though one participant alluded to "resistance to change course content/coverage." Another instructional faculty claimed that "Tenure Track faculty ignore the importance of a quality engineering education […] and just want to keep the status quo." But, the source of the resistance was not volunteered and would therefore benefit from further study.

Besides the existing curriculum and laboratory space, participants also noted other resources outside of engineering departments, such as industry partners and interdisciplinary collaboration, that could be beneficial to curriculum design, though challenging to manage. For example, one participant recommended leveraging interdisciplinary collaborations to integrate "business writing in addition to technical writing" in the curriculum. However, they also noted that the "business school [has] a barrier to access for engineering students." At least at one authors' institution, one possible barrier may be the restriction of enrollment in business courses to majors only. While this and other obstacles may currently exist, participants' awareness of potential interdisciplinary collaborations may indicate possible untapped curricular resources outside of engineering that could be pursued. Overall, these results may indicate gravitation away from large-scale change, due to a sense of them being too difficult to manage, toward identifying small and impactful strategies that require limited resources but have documented impact.

However, when considering differences across faculty roles, the instructional faculty drove the conversation around engineering curriculum enhancements, recognizing the largest number of resources and approaches available for expanding the curriculum. Tenure-line faculty only articulated two assets or challenges not identified by instructional faculty, while instructional faculty identified 13 unique assets and challenges out of the 17 identified overall. A similar pattern was noted in our prior work examining these faculty and their previous and intended use of the educational techniques and approaches discussed during the workshop. In comparison to their tenure-line colleagues, instructional faculty had a stronger interest in using the principles of intrinsic motivation in educational innovation, a stronger desire to increase their collaboration with colleagues, more frequently participated in faculty development activities, and were the only participants who explicitly discussed supporting student agency in their course designs (Coso Strong et al., 2019). This pattern suggests that within these engineering departments at HSIs, the instructional faculty are themselves resources for curriculum enhancements, contributing under-leveraged insight and experience.

5.3 Academic Partnerships

When asked about the partnerships engineering educators currently have or would need to develop to achieve their desired educational innovation, participants identified four distinct groups of partners. These partnerships include (1) *individuals at their own* or (2) *other academic institutions*, (3) *professionals in industry*, and (4) *government agencies* (Table 5). While participants did recognize that partnerships could provide unique support to educational innovation (e.g., real-world examples from industry partnerships, funding from government agencies and industry, and experience from other researchers or institutions), each group had its distinct challenges and limitations. For instance, while *industry partnerships* could provide funding, real-world examples, and internships, they were perceived as having narrow interests, offering too few internships, and being unreliable due to instability in the market. As one participant explained, "industry going through up and downturns lead to cyclic support." Nevertheless, the only partnership that participants explicitly linked to direct educational involvement was with industry. This inclusion of industry partners in the educational space is consistent with the growing recognition that there are opportunities to connect educational and professional experiences of engineers better, thereby preparing engineering students to tackle complex sociotechnological challenges and make engineering practice more inclusive and equitable (Brunhaver et al., 2018, 2019a,b; Stevens et al., 2013). This shared recognition of the value of partnerships with industry reflects discussions within the engineering education community regarding how the skills and knowledge that engineers use outside the classroom are rapidly changing with advances in technology and the pressing sociotechnical challenges of the future (Pleasants and Olson, 2019; Swartz et al., 2019).

Further, unlike other STEM disciplines, engineering is a profession with distinct licensure requirements (e.g., the National Society of Professional Engineers' Professional Engineer licensure), program accreditation requirements (e.g., ABET accreditation),

TABLE 5: Comparison across faculty roles of assets and challenges identified by participants related to academic partnerships across four subthemes

Academic Partnerships Themes				
Faculty Role	**Industry**	**Government**	**Internal Academic**	**External Academic**
Instructional faculty	+ Funding source – **Insufficient internships** – **Lacks engagement** – **Instability in market** – **Narrow areas of interest**		– **Lack of knowledge and training of colleagues** – **Resistance to change**	+ Individual researchers and designers + Other colleges and institutions
Both	+ Curricular support + Real-world examples			
Tenure-line faculty		+ Funding – **Politics and regulations**		

Note: All codes were identified with a plus icon (+) as assets. Bold items with a minus (–) were identified as challenges, and bold italic were identified as both assets and challenges.

and ethical codes of conduct. Therefore, maintaining links to practicing professionals helps create student learning objectives that better align with the profession's expectations and is commonly used as a benchmark in engineering program development and evaluation (Treuren and Jordan, 2019). Thus, this link also provides students with opportunities to practice their engineering skills, consistent with best practices in active learning (McConnell et al., 2017). Further, engagement with industry has the potential to advance diversity and inclusion efforts within engineering as a whole, including but not limited to providing Latinx students with opportunities to connect with Latinx alumni who can serve as role models (Revelo and Baber, 2018) and collaborating with institutions on local K-12 outreach efforts, scholarships, and internship opportunities (Secules et al., 2020). This emphasis on collaboration with industry may also reflect a recognition of Latinx students' at HSIs stronger intent to pursue work in industry as engineers rather than other career paths (Kendall et al., 2018a).

Governmental agencies were also seen as potential partners that could provide funding; however, as with industry, the organizations' interests and capacity limit the availability and use of those funds due to policies and regulations. For one tenure-line faculty member, these restrictions imposed on government-supplied funds even impact which students could participate at their institution, stating, "State funding rules force colleges and universities to reject students that do not fit the 'perfect' student mold."

Interestingly, none of the participants explicitly recognized other academics at their institution as an asset. Instead, as a participant pointed out here and in considering interdisciplinary collaborations for engineering curriculum enhancement, pursuing *internal academic partnerships* was challenging due to a sense that "there [are] not enough competent faculty members to share the load." However, participants saw *external academic partnerships* with individuals and units from other institutions as assets, given their experience as researchers or educational designers. As one participant stated, "other colleges are working on redesign and there are pathways for communication and support across institutions." One example is the HSI STEM Hub established by the NSF HSI program to serve as a resource promoting collaboration among HSIs, particularly those with little to no prior NSF funding (HSI STEM Hub, 2020). This pattern of emphasis on particular partnerships may indicate that faculty are more responsive to and trusting of support coming from outside their institution but have strict boundaries for the roles these partnerships can play (e.g., funding from government, in-class involvement for industry).

When comparing across educator roles, both tenure-line and instructional faculty groups recognize that partnerships with industry are beneficial in the classroom, especially as a source of real-world examples. Besides pointing to partnerships with industry, tenure-line faculty were the only group to note partnerships with government agencies, perhaps highlighting the research-focused nature of tenure-line faculty and the expectation for them to obtain extramural funding for research. Faculty that were not in tenure-line roles, however, emphasized internal and external academic partnerships. They again highlight how external partnerships were perceived as assets, but internal partnerships were seen as challenges. Therefore, when playing to their strengths, tenure-line faculty have access to government funding and nontenure eligible faculty bring a broader perspective on industry and academic partnerships that together may produce a more holistic approach to partnerships that are necessary for educational change.

5.4 Integration of Research and Education

Consistent with techniques espoused in the literature (Prince et al., 2007), participant responses converged on two general approaches for integrating research and education: (1) the *integration of research activities and outcomes into courses* and (2) *the use of research and educational lab space for learning* (Table 6). Participants connected the *integration of research activities and outcomes in courses* to positive impacts on student learning. As one participant described, "Linking faculty research with their teaching activity could increase their (and the students') engagement with class." Additionally, participants viewed academic research outcomes as a source of real-world examples for use in class. As one tenure-line participant suggested, educators can "use current research topics in ChE [chemical engineering] as fodder for 'real-world problems.'" The use of class time to create research proposal components was seen as an opportunity to help students learn about research by working on proposal development activities (e.g., preparing a part of the literature review that faculty could incorporate into their proposal). The only challenge participants identified with

TABLE 6: Comparison across faculty roles of assets and challenges identified by participants related to the integration of research and education across three subthemes

Integration of Research and Education Themes			
Faculty Role	**Integration of Research Activities and Outcomes in Courses**	**Research and Educational Laboratory Space**	**Impact of Integration**
Instructional faculty	+ Proposal development as learning experience for students + Linking of research and teaching efforts – **Willingness of faculty**	– **Modernization** – **Limited student slots** ***+/– Improved student-to-instructor ratio***	+ Student research competence + Improved technical skills
Both	+ Source of real-world examples	+ Existing research and educational lab space	
Tenure-line		– **Access policy in labs**	+ Increase student engagement

Note: All codes were identified with a plus icon (+) as assets. Bold items with a minus (–) were identified as challenges, and bold italic were identified as both assets and challenges.

integrating research activities and outcomes into courses was simply the faculty's willingness to do so.

In addition to using class time to facilitate research activities, the use *of existing research and educational laboratory space* was also identified as a viable approach for integrating research and education because "[…] labs can be used by faculty and students to learn and [do] research." These laboratory spaces were described as equally valuable resources for learning how to do research and gain hands-on skills in a one-on-one environment. However, the ability to do so hinged on the access policies in labs, the number of student slots in research labs, and the student-to-instructor ratio required to facilitate learning in a lab environment.

In their reflections, participants also discussed the *impact of integrating* research and educational activities and three benefits of doing so. Specifically, this integration could "increase student engagement in research labs," which, based on prior work by Zydney et al. (2002) is linked to improved student outcomes. Participants similarly linked this engagement with improvements in students' research competence, particularly at the graduate level, and technical skills as engineers.

When comparing responses across faculty roles, differences did emerge. Once again, instructional faculty were strong contributors, articulating all but two concepts for integrating research and education. Though familiar with academic research requirements and often experienced researchers themselves, instructional faculty do not necessarily have research responsibilities in their current positions; therefore most do not control their own laboratory space (Fitzmorris et al., 2020). As a result, they may perceive benefits to student learning, but, more tangibly, the barriers to integrating research into the student experience. This observation is reflected in how the instructional faculty articulated four of the five barriers to research integration: student-to-instructor ratio, lack of modern equipment, the willingness of faculty, and limited student slots. The fifth barrier, articulated by the tenure-line faculty, was access policies to labs.

Interestingly, none of the participants in the two target populations explicitly called out the value of educational research as a resource, though scholarship of teaching and learning was pointed out as an example in the worksheet. The only participant to note engineering education research as a resource was a staff instructor not included in the current analysis. Given that most HSIs do not yet have engineering or STEM education research centers or departments, this result may not be surprising or unexpected. Based on a review of their websites, of the top 25 institutions awarding engineering degrees to Latinx students, only five of the HSIs represented had departments or centers focused on engineering or STEM education research. Although this number is growing, it is likely that less than one-fifth of the approximately 50 HSIs offering engineering bachelor degrees have similar resources (APLU, 2018; Hasbún and Coso Strong, 2020). The development of the NSF HSI program, which was introduced to all workshop participants, may support the integration of educational research and teaching in the future. Yet, it may still be necessary to increase awareness nationally of engineering education research resources, such as the Alliance for Hispanic Serving Institutions Educators or the American Society for Engineering Education.

5.5 Student and Faculty Support

Four themes emerged that describe the types of student and faculty support participants noted as necessary to implement their innovation. These include supports that are (1) *student-focused*, (2) *faculty-focused*, and (3) *course or curriculum-based*, as well as the influence that (4) *institutional buy-in* has on the availability of these supports and resources (Table 7). While participants did recognize a range of resources available to students on their campus (e.g., advising, counseling, mentoring, career services), perspectives on why these resources were insufficient varied. For some, it was a sense that "students do not take advantage" of the resources. Others recognized that their students had competing responsibilities (e.g., work or family obligations) and circumstances (e.g., commuter, lack of family support) that made their ability to access these resources more limited, yet they still work hard on their coursework. These and similar patterns have been reported in the literature on STEM education and MSIs broadly (e.g., Crisp et al., 2009; National Academies of Sciences, Engineering, and Medicine, 2018). While most participants recognized students' responsibilities and circumstances as legitimate, some focused on what they perceived students were not doing. This focus illustrates deficit-based thinking. However, moving faculty beyond deficit-based thinking about their students' circumstances and actions will require more than acknowledgment but an intentional reframing of students' experiences as assets students can draw on and designing student support services to meet students where they are (Harper, 2010; Samuelson and Litzler, 2016).

TABLE 7: Comparison across faculty role of assets and challenges identified by participants related to student and faculty support across four subthemes

Student and Faculty Support Themes				
Faculty Role	**Student-Focused Support**	**Faculty-Focused Support**	**Curriculum- and Course-Based Supports**	**Institutional Buy-In**
Instructional faculty	+ Students are highly engaged ***+/– Students do not take advantage of support***	+ Staff support ***+/– More autonomy*** ***+/– Other faculty, e.g., design faculty, but concerned about the number of competent faculty***	+ Academic review committees to provide feedback ***+/– More internships for students***	+ Students buy-in exists **– Heavy emphasis on nonteaching responsibilities**
Both	+ Academic tech./IT/web support ***+/– Student-faculty interactions (advising, mentoring, etc.) but advising needs are different for each student*** ***+/– Students' availability to access campus resources and complete assignments (commuters, family obligations, etc.)***†	+ Incentives to innovate in class **– Not enough time due to heavy workload** ***+/– Culture of cooperation and collaboration, but in conflict with a culture of individualism*** ***+/– Professional development opportunities, workshops, and resources, but need time and guidance***	+ Previous students as tutors/peer leaders **– Healthy student-to-instructor ratio** ***+/– More TA support***†	**– Faculty buy-in and resistance to change** **– Institutional barriers (e.g., funding, recognition, load, priorities)** ***+/– Admin. buy-in and resistance to change***
Tenure-line	**– Lack of family support**			

†Tenure-line faculty saw this as an asset only.
Note: All codes were identified with a plus icon (+) as assets. Bold items with a minus (–) were identified as challenges, and bold italic were identified as both assets and challenges.

Second only to financial resources discussed later, 17 participants acknowledged the tension between available time for educational innovation and, as one participant put it, “The biggest barrier is time. Instructors have many demands on their time.” For example, faculty participants acknowledged their roles as mentors and advisors as a necessary student-focused support (Dennehy and Dasgupta, 2017). However, faculty expressed concern about their struggle with innovating in this space due to how the “advising needs are different for different students, [producing] information overload.” Participants repeatedly noted that their time is limited, highlighting a tension between their desire to serve and the impact this support has on a resource that these participants felt was lacking for themselves. Other participants attributed this lack of time to a large course load, an overload of service activities, and research responsibilities. While participants identified existing professional development opportunities to support their innovation work, again, the lack of time coupled with the need for guidance on how to innovate impacted their ability to utilize those resources. They “need guidance on how to modify class and move away from pure lecture.” Participants also recognized that collaboration and cooperation, particularly with other faculty, would help achieve their educational innovation and perhaps help relieve the time constraints. However, while some faculty sensed a “culture of sharing and collaboration” at their institution, others noted a lack of cooperation due to a “culture of individualism.” As with the discussion of internal academic partnerships, participants also expressed their concern about finding enough faculty they deemed “competent” collaborators.

In considering the supports available to students and faculty in the classroom and for developing educational experiences, participants cited the help that their prior students could provide as teaching assistants (TAs), tutors, and peer leaders. Participants also pointed to an example shared about an HSI engineering program leveraging student-instructors in an introductory course (Montoya et al., 2015). However, the participants noted a need for more TAs and smaller class sizes such that a “proper faculty/student ratio” was achieved. Further, a participant mentioned how “academic review committees can provide feedback on sequential course effectiveness.” As discussed previously, participants wrote about industry partnerships as curricular support (e.g., in the form of in-class examples, guest speakers, and internships) and the potential benefit (e.g., in the form of in-class examples) of integrating research and education.

Finally, participants noted the need for buy-in from three stakeholders to support their educational innovation: other faculty, administrators, and students. Of the three, student buy-in was noted as already existing. As one participant described it, “Students are ready for this change; they are waiting for it to be realized.” Concerning faculty and administrators, participants noted that getting faculty buy-in was a challenge due to their resistance to change, despite being part of that stakeholder group themselves. Linked to this was their concern about how there was a disproportionately heavy emphasis on nonteaching responsibilities. One instructional participant went so far as to claim that “tenure-track faculty ignore the importance of a quality engineering education.” Participants’ perception of administrator buy-in, however, was mixed. At least at the college and departmental level, some felt that they had the support of leadership. Beyond the department and college, participants expressed concern about institutional barriers (e.g., funding, recognition, workload, priorities) and the fact that "college leadership may not see this as relevant."

More than any of the other categories, there was considerable agreement across educator roles on their perspective of assets and challenges related to student and faculty support needed to develop solutions to the individual design challenges. The challenges facing all faculty groups relate to a sense that they lack buy-in from other faculty and administrators, lack time to be innovative, and cannot innovate with so many students in their courses. In attempting to overcome some of these challenges, all groups acknowledged the presence of incentives to innovate, the existing TA support, and the large variety of resources and services available for students and faculty on campus. However, instructional faculty also recognized the assets available to them from outside the institution, i.e., academic review committees and internships, and the students themselves, particularly their readiness for change.

5.6 Physical Infrastructure and Other Resources

The final category of participant responses encompasses the physical infrastructure and other resources that participants sense they need to implement their innovations. Three subthemes emerged: (1) *physical space*; (2) *materials, supplies, and equipment*; and (3) *financial resources* (Table 8). When considering the *physical spaces* needed to complete their activities, most participants recognized the existing spaces on their campus as assets. Still, they expressed a general sense of needing more of these areas. As one instructional faculty member observed, "we are very limited in space for lab activities." While some spaces (e.g., computer labs, makerspaces, and laboratories) were associated with facilitating the use of certain technologies, most spaces participants identified relate to their ability to encourage collaboration on campus. For faculty, "If there is a physical space for instructors to collaborate, it may increase interaction." For students, more space to meet and gather to study in groups was perceived as beneficial. All physical spaces articulated by participants were those commonly found on most campuses.

When considering the *materials, supplies, and equipment* needed for their proposed innovation, participants pointed to existing software, laboratory hardware, computers, and lab supplies (though some outdated) as assets. However, participants did note that not all resource allocation and availability is equitable, "Some students don't have internet [or] computers," and more were needed overall.

Of all the subthemes, *financial* resources were a shared need across 18 of the participants. While articulating various funding sources (e.g., industry, local government, grants), participants still sensed a need for additional financial resources. The challenges participants expressed regarding obtaining funding suggested that available funds from awarding organizations are shrinking, resulting in increased competition. As one instructional participant pointed out, this increased competition is daunting since they have "no external funds (NSF, etc.) yet" and therefore may not have the same training and experience as other faculty with established research programs and history of

TABLE 8: Comparison across faculty roles of assets and challenges identified by participants related to physical infrastructure and other resources across three subthemes

Physical Infrastructure and Other Resources			
Participant Group	**Physical Space**	**Materials, Supplies, and Equipment**	**Financial**
Instructional faculty	+ Makerspace ***+/– Computer labs, but some need more time allocation***	***+/– Lab supplies, but some are old*** ***+/– Computers for students, but not all students have computers or internet*** ***+/– More are needed to support undergrad research***	+ Funding/grants make the administration care + Travel support **– No external funds (e.g., NSF) yet** ***+/– Grants are competitive to get***
Both	**– More space in general** ***+/– More laboratory space*** ***+/– More meeting space***† ***+/– More group study space***†	+ Software + Lab hardware	**– Not enough funding**
Tenure-line	+ Instructor collaboration space	+ Learning devices	+ Funding from industry or government **– Return on investment is difficult to determine** **– Maintaining/ sustaining innovations** ***+/– State funding is limited and diminishing***

†Instructional faculty identified as an asset only.

Note: All codes were identified with a plus icon (+) as assets. Bold items with a minus (–) were identified as challenges, and bold italic were identified as both assets and challenges.

funding. This need for funding was echoed by the listening sessions informing the NSF HSI program and in its subsequent grant solicitations that reserve funding tracks for institutions new to NSF (National Science Foundation, 2017; NSF EHR Subcommittee, 2017a,b). Funding plays a role in providing physical space, materials, supplies, and equipment needed to implement their curricular innovation. It also serves as political capital required to influence administrators. As one instructional participant pointed out, "Funding [and] grants can make the administration care." Concern was also expressed about the ability of innovations to be maintained or sustained, such as an innovative advising system. Historically, at one author's institution, innovations have often only lasted until the start-up funds were used. Their institution has struggled to execute a plan to sustain innovations after grant funds have been exhausted. This lack of sustainability following the award period is a common phenomenon that has motivated funding mechanisms to explicitly ask for sustainability plans (e.g., VentureWell Faculty Grants solicitation, National Science Foundation HSI Program).

When considering faculty roles, the resources participants emphasized tended to reflect resources historically associated with their position. Tenure-line participants, while expressing needs for additional space, focused on sources of funding. This focus may indicate the expectation for tenure-line faculty to obtain extramural funding and a devaluation of unfunded projects. In comparison, instructional faculty recognized the resources in the other two subthemes nearly equally. This may point to a propensity for instructional faculty to see funds as a tool rather than a starting point. Of note were the varying perspectives of the groups toward physical spaces. While tenure-line faculty felt more was needed, instructional faculty saw existing spaces as only assets. This perception of whether they have sufficient resources may also be institution-specific, since some instructional faculty felt there was no need for additional support while others felt there were limited resources in general.

6. LIMITATIONS

A small subset of the workshop attendee data was omitted from the current analysis, as it represented responses from nonfaculty participants (i.e., educational development staff and administrators). However, because some activities involved group-based participation, the responses of the 24 participants may have been informed by the perspectives of participants who were omitted from the direct analysis. Furthermore, during the analysis phase, participant responses were clarified by comparing them with their previous artifacts. In addition, this study focuses on the perspectives of faculty. Therefore, conducting a similar exercise with students and administrators may reveal different views about the same educational innovations. The handout used for analysis was based on an activity that required participants to provisionally commit to an idea or innovation to explore throughout the workshop series. By focusing on this handout, we recognize that faculty may have had other interests they wanted to explore but chose not to due to the initial brainstorming's collaborative nature. Further, the activity was open-ended, potentially resulting in faculty not thinking about or not remembering particular assets or challenges. The prompts included in the worksheet sought to alleviate this limitation. Further, the workshop design guided participants to iterate on ideas, and the selected educational innovation represents their final iteration that the faculty participants felt was the most pressing and most accessible. Consequently, the results represent the assets and challenges related to the educational innovations participants felt were most critical, rather than an exhaustive list.

This qualitative study focuses on a self-selected subset of 24 engineering educators from HSIs across the southern United States (Arizona, New Mexico, Texas, and Florida). While the study was designed to gather perspectives from engineering educators represented across different faculty roles and institutions, future work should consider

HSIs in other regions of the country (i.e., New York, Illinois, California) to determine whether these findings are indeed region-specific or have broader implications. Given the nuances of curriculum innovation and each institution's context, future work should leverage methodologies that support a deeper understanding of institutional context and an individual faculty member's experience.

7. KEY FINDINGS AND IMPLICATIONS

Overall, this qualitative study sought to build empathy with and understand the perceptions of engineering faculty members at HSIs as it related to their ability to engage in educational innovation and, ultimately, to design learning experiences that are inclusive and student centered. During the two-day workshop, engineering faculty participants completed various design thinking exercises to explore their own experiences and perceptions, and generate ideas for educational innovation at their institution. An examination of workshop artifacts illustrated how engineering educators at HSIs (1) desired to support their students' intrinsic motivation and agency in learning, and (2) recognized assets within and outside of their institutions that they could leverage to innovate within their courses and departments. At the same time, these educators also acknowledged barriers to innovation from various sources, including personal, interpersonal, and administrative (e.g., funding, individual time, access to labs, and research opportunities for students). The differences in the perceptions across educator types highlighted an opportunity to connect and support collaboration between different faculty types in order to bring different perspectives and skillsets to educational innovation projects. The subsequent section summarizes these key findings, along with research and education implications associated with them.

7.1 Assets and Challenges to Educational Innovation in Engineering at HSIs

After brainstorming and selecting their stakeholder-challenge pair, participants generated ideas for addressing these particular design challenges while maintaining alignment between their goals and their stakeholders' needs. The participants then reflected on the assets and challenges for implementing their educational innovation at their respective HSI within five key areas:

- ***Engineering curricular enhancement*:** Within this category, the educators discussed (1) pedagogical approaches and activities that support learning, (2) perceived resources that support curriculum innovation, and (3) factors that impact student learning. Across the subcategories, there was a general focus on *how* we teach instead of *what* we teach. Yet the tension around content was still present across all those in attendance as they considered how to innovate in an already "full curriculum." These results potentially suggest comfort with incremental changes that require limited resources and involve fewer challenges.

- ***Academic partnerships*:** The faculty participants discussed four types of partnerships: (1) individuals at their own or (2) other academic institutions, (3) professionals in industry, and (4) government agencies. Nevertheless, the only partnership that participants explicitly linked to direct educational involvement was with industry. While some faculty still indicated challenges with partnering with industry, there appears to be an opportunity to enhance educational innovation at HSIs through industry collaborations.
- ***Integration of research and education*:** Faculty saw value in the integration of research and course activities but recognized critical challenges. They discussed how this integration was dependent on the faculty's willingness to bring their research to the classroom as well as barriers to accessing research labs and spaces for students and, in some cases, instructional faculty. Additionally, none of the participants in the two target populations explicitly called out the value of educational research as a resource, though scholarship of teaching and learning was pointed out as an example in the worksheet. Therefore, there may be an unmet need to support engineering education research at HSIs and increase awareness of engineering education research resources, such as through the Alliance for Hispanic Serving Institutions Educators.
- ***Student and faculty support*:** Faculty considered supports and barriers for educational innovation at multiple levels: (1) student-focused, (2) faculty-focused, and (3) course or curriculum-based. In addition, faculty acknowledged the influence of (4) stakeholder buy-in at these multiple levels (i.e., student, faculty, and administrator). Overall, the descriptions in the artifacts articulated an interconnectedness between an individual faculty member's time, their engagement with students inside and outside the classroom, and buy-in for educational innovation (from the faculty member themselves, a faculty colleague, or administrator).
- ***Physical infrastructure and other resources*:** Faculty described assets and challenges related to (1) physical space, (2) materials, supplies, and equipment, and (3) financial resources. The dominant shared need across a majority of the participants was funding.

7.2 Implications for HSI Faculty, Administrators, and Staff

When considering the assets and challenges articulated by the faculty, there are many potential implications for both educational practice and the development of new educational innovations. For example, given that partnerships were viewed as assets for both funding and, in the case of industry, curricular support reasons, there is an opportunity for engineering colleges and departments at HSIs to connect faculty more closely with business development and related offices. By making visible the needs of faculty and the opportunities for industry and foundations to connect with students more closely, a closer relationship between these groups could help create new avenues for funding and, more broadly, curriculum development and innovation. Another curricular implication concerns the integration of research and course activities. The willingness of faculty to bring research into the classroom may be facilitated by engaging with the HSI's teaching and learning center or related centers regarding *how* that integration could occur or by explicitly valuing this integration in annual evaluations. Lastly, given the differences noted in the results section between these educator types at HSIs, collaboration among different faculty types would appear to be an opportunity to bring different perspectives and skillsets to educational innovation projects. For instance, department chairs and deans could consider intentionally creating curriculum innovation committees that incorporate multiple educator types (i.e., tenure-line, instructional, part-time/adjunct).

For emerging HSIs or non-HSIs, this study can provide a framework for examining faculty perceptions of their assets and challenges with educational innovation. The activities enable critical reflection on the availability and accessibility of institutional resources. By engaging in these activities with one's faculty, administrators and staff may be able to support the launch of new or sustain existing educational innovations by connecting faculty with existing resources, gather new resources, or provide more access to resources where possible (i.e., time, course releases, space, funding).

7.3 Implications for Researchers

From a research perspective, the workshop activities enabled the identification of faculty perceptions of their assets and challenges with educational innovation at their institution. Future work should focus on documenting and examining faculty experiences implementing educational innovations to determine the extent to which these assets and challenges align and are comprehensive. In addition, many of the assets shared by multiple participants were focused on resources (i.e., funding, physical space, time). Viewing these resources as assets is in contrast to some HSI research literature that focuses on the under-resourced nature of many HSIs. As such, research could further explore the role of resources in success cases of educational innovation at HSIs. Lastly, the tension around a "full curriculum" should be explored further. By better understanding how faculty at HSIs, and possibly also industry, define the critical competencies of engineering majors, researchers, along with faculty developers, would be more equipped to engage in educational innovation discussions with departments and individual faculty members.

While there were strong trends across all faculty participants regarding the assets and challenges mentioned, there were still noticeable educator role-type differences. Instructional faculty led the discussion around engineering curriculum enhancements. Additional research is needed to better understand why and whether this phenomenon would extend beyond those who self-selected to participate in the workshop. Across the resources identified by the faculty, there was a noticeable trend in tenure-line faculty focusing on funding. These differences reinforce a need, also noted in our prior work (Coso Strong et al., 2019), to better understand the experiences of these HSI faculty as they pursue educational innovation at their institutions and understand their experiences pursuing professional development in educational change and instruction. In addition, the diversity of individuals in instructional faculty roles (i.e., professors of practice, full-time adjuncts, instructors/lecturers) suggests a need to further understand this population and their values, needs, and experiences.

8. CONCLUSION

Engineering programs at HSIs are uniquely equipped to enrich the outcomes of Latinx and other traditionally marginalized students through existing and new inclusive and student-centered educational innovations both inside and outside of the classroom. Faculty play a critical role in supporting students at HSIs by developing courses and curricula that elevate the student voice and recognizing students' backgrounds, strengths, interests, and goals. Yet, as this study indicates, while engineering faculty at HSIs perceive that their institutions and departments have assets that can enable educational innovation in engineering, there are still challenges. Overall, this study provides a foundation for future research on factors impacting faculty engagement with inclusive and student-centered pedagogy at institutions where Latinx and other racially and ethnically diverse students comprise a significant percentage. By making explicit these assets and challenges at HSIs, we can begin to understand the engineering educational environment at HSIs and develop approaches for supporting faculty efforts toward curricular innovation.

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