Co-Designed Research Agenda to Foster Educational Innovation Efforts Within Undergraduate Engineering at HSIs

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An Assistant Professor at The University of Texas at El Paso, Dr. Meagan R. Kendall is helping develop a new Engineering Leadership Program to enable students to bridge the gap between traditional engineering education and what they will really experience in industry. With a background in both engineering education and design thinking, her research focuses on how Latina/Latino students develop an identity as an engineer, methods for enhancing student motivation, and methods for involving students in curriculum development and teaching through Peer Designed Instruction.

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Dr. Basalo is an Assistant Professor in Practice in Mechanical and Aerospace Engineering at the University of Miami. Prior to joining the University of Miami in 2014, she worked as an adjunct professor at Columbia University and the Cooper Union in New York City. She received her PhD from Columbia University in 2006, where her research focused on the mechanical and frictional properties of articular cartilage. Dr. Basalo 's teaching experience includes Thermodynamics, Computer Graphics, Materials Science and laboratory courses. Since 2015 she has been actively involved in the University of Miami College of Engineering's "Redefining Engineering Education" strategic plan on educational innovation. As part of this plan, Dr. Basalo worked with 2 other faculty members to organize inaugural Senior Design Expo in May 2017, an exposition where over 200 senior students showcased their Capstone projects to the University of Miami community, alumni and industry leaders. Starting in 2016 and through her work with the University of Miami's Engaged Faculty Fellowship program, Dr. Basalo incorporated an academic service component into the final project for a sophomore-level Measurements Lab course.

Dr. Alexandra Coso Strong, Florida International University

As an assistant professor of engineering education at Florida International University, Dr. Alexandra Coso Strong works and teaches at the intersection of engineering education, faculty development, and complex systems design. Alexandra completed her doctorate in aerospace engineering at Georgia Tech in spring 2014. Prior to attending Georgia Tech, Alexandra received a bachelor's degree in aerospace engineering from MIT (2007) and a master's degree in systems engineering from the University of Virginia (2010). Alexandra comes to FIU after completing a postdoctoral fellowship at Georgia Tech's Center for the Enhancement of Teaching and Learning (CETL) and three years as a faculty member at Olin College of Engineering in Massachusetts. Alexandra's research aims to improve the design of educational experiences for students by critically examining the work and learning environments of practitioners. Specifically, she focuses on (1) how to design and change educational and work systems through studies of practicing engineers and educators and (2) how to help students transition into, through and out of educational and work systems.

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Abstract

The responsibility to educate and empower underrepresented groups in undergraduate education often relies on the commitment of educators and the curricula they design. Without financial or institutional support, there are limited opportunities for educators from different Hispanic-Serving Institutions (HSIs) to engage in conversations about their curricula developments and share their vision for the future of engineering education. This multi-institutional research project adopted a participatory research design to recognize the existing efforts of educators and foster their curricula and scholarship ideas. A series of three workshops were conducted in 2018 by visiting educators engaged in engineering education at both two and four-year HSIs. Before, during, and after the workshop series, attendees were asked to reflect on three guiding educational philosophies: intrinsic motivation, students as empowered agents, and design thinking. Thirty-six engineering educators from thirteen HSIs from across the Southern United States participated in one of two, two-day workshops where attendees prototyped examples of how they would implement these philosophies at their home institution. Using these prototypes, participants identified the assets they already had and resources they would still need to obtain. Following a thematic analysis of these prototypes from the initial workshops, five themes were identified and prepared for dissemination at the third workshop. Ten participants from the initial workshops attended the final workshop conducted at the 2018 ASEE Annual Conference, and an additional five participants joined as general ASEE Annual Conference attendees. In the final workshop, participants engaged with the preliminary results, further reflected on their progress since the first workshop, and brainstormed research questions they believed the engineering education research community would benefit from answering. The results of this research paper are based on the perspectives of forty-one engineering educators, with a focus on qualitative analysis of questions proposed from fifteen participants at the final workshop. Five research areas emerged: *Engineering curricula enhancement, Understanding our students, Faculty development relevant to HSIs, Perceptions of instructional faculty, Long-term impactful approaches.* This paper therefore aims to support broader engagement in research and collaboration with and within HSIs, with a goal of increasing the representation of Latinx students in engineering. The results have the potential to target and foster further collaborative scholarly research between educators and promote their curricular efforts in undergraduate engineering education at HSIs.

Motivation: Representation of HSIs in Engineering Education Research

In the 2017 Dear Colleague Letter (DCL) [1], the National Science Foundation put out a call to researchers to help identify ways to improve STEM undergraduate education at Hispanic-Serving Institutions (HSIs). When considered together, the disciplines of Science, Technology, Engineering, and Math (STEM) encompass a vast array of potential stakeholders, professional certification requirements, and unique degree plans. Therefore, to better identify impactful research in response to this DCL, this project sought to focus on a component of STEM and examines trends in undergraduate engineering education at HSIs.

After decades of focus on increasing diversity in engineering, Latino and Latina (Latinx for short, inclusive of Hispanic, Boricua, and other Spanish-speaking cultures) students continue to be underrepresented in undergraduate engineering education programs. In 2016, the percentage of engineering bachelor's degrees awarded to Hispanic students was 10.7% [2]. With these individuals estimated to make up 17.1% of the United States population, they are still markedly underrepresented in engineering [3]. Continued work is necessary within higher education institutions to identify opportunities to increase the representation of Latinx students in engineering. One possible approach to improving the diversity of the engineering profession is to examine the educational system that is training these future engineers, particularly at Hispanic Serving Institutions. Overall, 472 HSIs enrolled nearly two-thirds of Latinx undergraduates in 2016 [4]. Of Hispanic students pursuing engineering degrees, at least 59% obtain their degrees from HSIs [5]. To increase the representation of Hispanic individuals in the engineering field, this project sought to focus on identifying and amplifying the successful efforts already in place at HSIs and develop approaches to address areas still needing refinement in existing and emerging HSI engineering education programs.

Within the engineering education community, researchers and educators have pursued small- and large-scale change efforts to support recruitment and retention of students, the development of evidence-based educational practices, and implementation of authentic assessments and frameworks for understanding students' and educators' experiences and development [6]. Even with extensive research in these areas, however, the focus of much of this research has not been students, staff, and educators from HSIs. In fact, based on a review of their websites, of the top 25 institutions awarding engineering degrees to Hispanic students [5], only three of them have an engineering education department, five have dedicated engineering education research centers, and six others have STEM centers or institutes. Currently, engineering education research efforts are largely occurring at large, four-year, primarily-white research institutions. Due to the non-HSI status of most of the institutions researching engineering educational reform, limited attention has been given to studying the formation of engineers at HSIs. This lack of understanding of what is needed to amplify the efforts of HSIs to appropriately educate Latinx undergraduate engineering is, therefore, the focus of the research project.

Research on engineering education reform highlights the importance of understanding barriers to change and the impacts of the environmental, historical, and systemic constraints on reform efforts [7]. In addition, research on educational change emphasizes that effective strategies for reform require alignment with the beliefs of the individuals involved or must seek to change those beliefs [8]. With that in mind, there exists a need to learn from individuals who would benefit from and/or engage with future research at HSIs, the engineering educators themselves. This project consisted of a workshop series targeted toward engineering educators from HSIs not necessarily engaged in engineering education research or scholarship. By doing so, engineering educators at HSIs are engaged in a conversation intended to identify the non-obvious needs and existing successes at HSIs that can be addressed and amplified in future NSF initiatives to improve undergraduate STEM education. This paper reports on areas educators perceived as needing further research and investment and aims to serve as a foundational research agenda for initiatives fostering undergraduate engineering education at HSIs. As a result of the research project, other forthcoming research papers from the authors address the topics of 1) the impact of faculty development workshops on instructional faculty at HSIs, 2) faculty perceptions of student characteristics at HSIs, and 3) faculty perceptions of curriculum innovation.

Methodology

Research Project Overview

This research paper is an outcome of a collaborative, mixed-methods research project that focused on engaging engineering educators at HSIs to share non-obvious needs and existing successes at their institution. The multi-institutional committee consisted of two engineering education researchers and faculty developers, two instructional engineering faculty, an instructional designer, one graduate and three undergraduate research assistants all engaged in education development at their institutions. The four authors of this paper organized, led, and facilitated the workshops. A participatory research design [9] was adopted by creating and leading three faculty development workshops, inviting individuals who are engaged in engineering education at both two- and four-year HSIs. Throughout the research project, participants were required to complete a series of data collection activities: a pre and post-workshop survey, handouts during each workshop, and a follow-up survey in the fall semester of 2018. These activities were framed as exercises for participants to reflect upon their teaching, institutional context, and design educational innovations to implement at their institution after the workshops. To engage engineering educators from different institutions and reduce the financial barrier to attend a faculty development event, the first two, two-day workshops were held in at institutions in Texas and Florida, states with some of the highest concentrations of two- and four-year HSIs [4]. The first workshop was hosted at The University of Texas at El Paso, while the second was held at the University of Miami in consideration that both institutions are listed in the top 25 institutions awarding bachelor's degrees in engineering to Hispanic students [5].

Leveraging Three Powerful Ideas to Identify Research Needs

The research project design was organized around providing multiple opportunities for participants to explore their institutional context and adopt the tools of prototyping and iteration [10][11]. During the initial workshops, participants were introduced to three powerful educational philosophies that connect to positive learning outcomes: *intrinsic motivation*, *students as empowered agents*, and *design thinking*. Intrinsic motivation refers to a person performing an action because it is inherently interesting rather than from external consequences [12]. Intrinsic motivation was therefore introduced as a lens for participants to examine their students' autonomy to control their own learning, evaluate their competence, and relate to engineering topics within a course [12]. Participants then engaged with factors that may impact how students can become self-directed, reflective, and empowered agents of their own learning [13][14][15]. Design thinking principles were then introduced to participants as a framework for prototyping learned-centered activities that considered their students' sense of motivation and agency. Participants leveraged these ideas to reflect upon their own teaching practice, capture insights about challenges and opportunities at their institution, and generate ideas for educational reform at HSIs. A follow-up workshop took place at the 2018 ASEE Annual Conference & Exposition to disseminate and engage participants with preliminary results from the first two workshops. The findings from this paper were developed as a result of the final workshop.

2018 ASEE Annual Conference and Exposition Workshop

Of particular relevance to this paper, the final three-hour workshop of the series consisted of sharing preliminary results with participants through an introductory presentation, a member-checking activity, a research question generation activity, and a reflection activity. For the member checking activity, participants were divided into groups corresponding to each of the four major themes identified from the preliminary analysis of the initial workshop results: *Student Characteristics, Challenges and Barriers, Opportunities and Needs, Interventions and Assets.* Each group was provided with a prompt related to one of the major themes and then asked to complete the following activities on a wall poster: 1. React to the prompt and record responses on post-it notes. 2. Rotate, as a group, to the next theme and review, group, and refine ideas related to the new prompt, combining ideas with those of the prior group. 3. Rotate, again as a group, to the next theme and review, group, and refine ideas from the prior team as well as the ideas identified by the research team during preliminary analysis. 4. Rotate again, review responses to the final prompt, and prepare a brief presentation of the responses for the group. The prompts included:

> *"What are the characteristics of students we are teaching at HSIs?"*
> *"What challenges or barriers do you think prevents innovation in engineering education at HSIs?"*
> *"What opportunities and needs do you see for innovating in engineering education at HSIs?"*
> *"What interventions and assets have you found already exist for innovating engineering education at HSIs?"*

After the completion of the member checking activities, participants were asked to complete two individual activities to design a research question and reflect on actionable steps to addressing one of their most pressing research questions. The focus of this paper are the participant responses to the research question activity '*Design your research question*' [Appendix I].

Participants

The workshops applied voluntary and convenience sampling methods to engage engineering educators at HSIs. Participants for the first two workshops were recruited via a call for applications posted to the workshop website and distributed via personal emails and appropriate ASEE engineering education listservs and newsletters. The selection criteria for the initial workshop included: completion of the workshop application, an institutionally assigned instructional role at an HSI, more than two years of teaching experience in engineering at their current institution, and willingness to participate and complete assigned activities. The follow-up workshop engaged engineering educators from each workshop as well as attendees at ASEE. Five participants from each workshop were provided with stipends to attend ASEE. To be eligible for the stipends, participants had to agree to attend ASEE and the workshop, have completed a majority of workshop activities, and not have attended ASEE previously. Participants were also selected for diversity of institution and faculty type. Five other participants from the general ASEE population attended the follow-up workshop. No demographic information was collected from the ASEE workshop participants that did not attend one of the prior workshops, however institutional affiliation was collected. All five participants represented HSIs or emerging HSIs.

Forty-one participants from sixteen institutions from across the United States (from Arizona, New Mexico, Texas, Florida, California, and Washington) attended the workshops. Five institutions were represented by the 18 participants at the Florida workshop, 8 institutions by the 18 participants at the Texas workshop, and 11 institutions (of which 3 were not represented at the initial workshops) were represented by 15 participants (5 did not attend either of the initial workshops) at the ASEE workshop [Fig.1]. Across the workshops, there were two private 4-year, ten public 4-year, and four 2-year institutions. Of these institutions, all those represented at the initial workshops were considered Hispanic Serving Institutions based on having over 25% of their student body identifying as Latinx/Hispanic [16]. Of the new institutions represented at the ASEE Workshop, two were considered emerging HSIs and the third is an HSI.

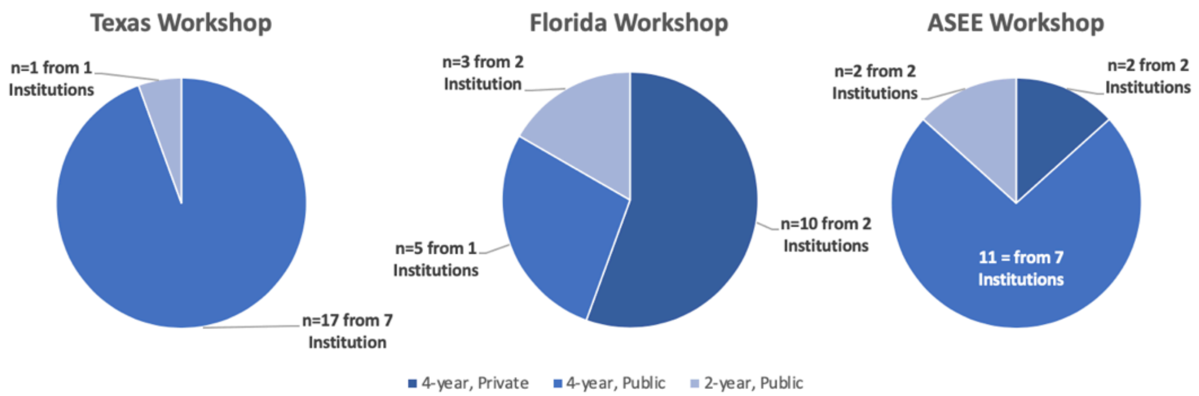

Fig.1: Institutional representation at the workshops.

The educators attending these workshops included a diverse set of engineering instructors. From those participants who reported demographics, 42% were tenured or tenure-track faculty, 44% were instructional faculty (professional and non-tenure track), and 17% were part-time lecturers, staff, or administrators with instructional responsibilities [Fig.2]. Twenty-five percent of attendees identified as women [Fig.2] and 39% identified as Hispanic (the same at both the Texas and Florida workshops).

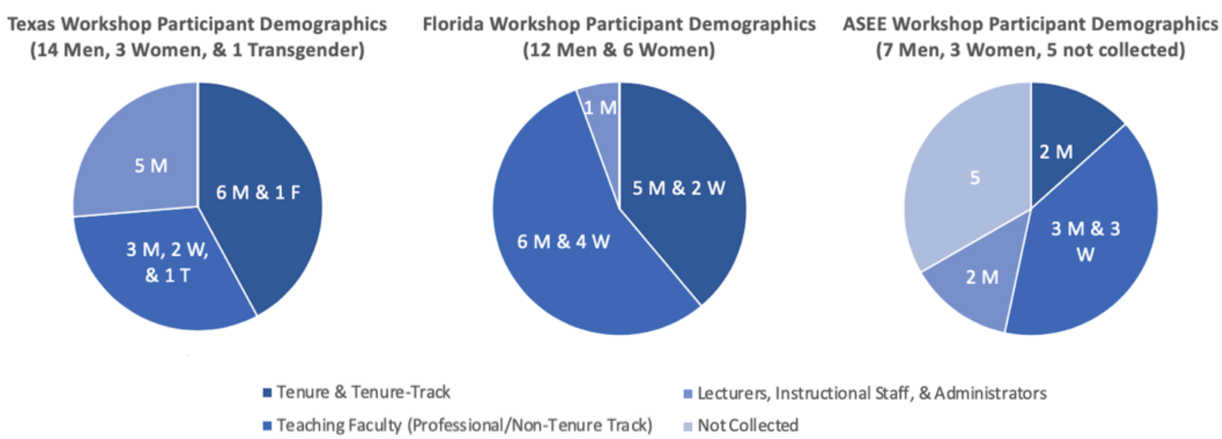

Fig. 2: Demographics of participants at each of the workshops.

Data Collection and Management

This paper focuses on the qualitative data collected after the member checking activities within the final workshop, through an activity titled *'Design your research question.'* This activity invited participants to address the preliminary results, contextualize the research according to their institutional needs, and suggest research areas for the wider academic community to pursue. In the '*Design your research question'* activity, each participant was asked to select a research area (interventions and assets, student characteristics, opportunities and needs, or challenges and barriers) to focus their research question and provide a rationale for their choice. Once an area was selected and explained, participants were asked to select the individuals or groups they wish to study, explain what areas they were interested in studying further, and, lastly, brainstorm multiple research questions and corresponding hypotheses. Participants recorded their responses by writing on the handouts that were then deidentified and scanned. The data was then transcribed, organized, and digitally coded using Microsoft Excel. Ellipses were applied when handwriting was ineligible for transcription, any language or spelling errors were corrected, with square brackets employed for missing words.

Data Analysis
Throughout the analysis of results for this paper, a single researcher performed the coding of participant responses and presented preliminary results to the research team to ensure consistency in interpretation of codes before further analysis. Discrepancies and initial finding were discussed before the single researcher synthesized coding and results. For this paper, an open-coded approach was performed on each response collated from the *'Design your research question'* handout as it offered a richer opportunity to capture the perspectives of engineering educators within the workshop and synthesize their reflections of the preliminary results. The analysis involved a close reading to capture key phrases from participants and applying a constant comparative analysis to surface common relationships between the data.

During analysis, all responses were grouped by the questions from the handout, with initial analysis executed on a question-by-question basis. A quote-by-quote reading and in vivo coding was then performed, by assigning an initial code to each participant response, using the language provided by the participant. A total of 89 unique in vivo codes were generated across 14 participant handouts. Focused, secondary coding was performed through a comparative analysis across all in vivo codes, with 89 unique codes reduced to 48 codes. To further group and refine the final language of emerging categories and areas, these codes were then compared with five themes used in the thematic analysis of previous handouts: *Student and Faculty Support, Engineering Curricula Enhancement, Integration of Research and Education, Partnerships with Industry or Other Academic Institutions, Physical infrastructure and other resources*. The codes were then grouped into five overarching research areas, to assist in interpretation of results.

Results and Discussion

Five core research areas emerged from the analysis of responses from the participants: *Engineering curricula enhancement, Understanding our students, Faculty development relevant to HSIs, Perceptions of instructional faculty, Long-term impactful approaches*. Presentation and discussion of results are shared according to these five research areas.

(1) Engineering Curricula Enhancement
Due to the design of the ASEE workshop, the majority of coded responses about curricula change within engineering education was expected. However, the three categories that structured this research area appeared to represent three systemic levels to approach curricula enhancement,

curriculum development strategies, multiple pathways to an engineering degree and the *hidden curriculum*. A summary of coded responses, categories and examples of research questions articulated by ASEE workshop participants are detailed in [Tab. I].

Curriculum development strategies

The category *curriculum development strategies* included codes responses related to researching practical and actionable activities educators can introduce and therefore control within their teaching. Specifically, participants articulated an interest in investigating methods for students to apply course materials through project-based, hands-on, experimental, or research-based learning activities within engineering curricula, specific and relevant to the context of HSIs. As illustrated by the research question generated by one participant, *"What active learning practices are effective for HSI students and affordable for our institution?"* participants placed an emphasis on taking into consideration 'affordability' when investigating effective active learning strategies for HSIs. The participant's response illustrates a potential avenue to contextualize existing active learning educational research according to the existing assets within low-resource HSIs. A similar thread emerged across responses, to surface existing theories or strategies to design 'experiential learning' and 'disciplinary research' specific to HSIs. For example, one participant placed value on learning from the perspectives of their peers, who embrace or reject particular strategies: *"I have seen varied perceptions from faculty regarding experiential learning practices [...] I would like to know more about why some faculty embrace it and others do not."* This same educator identified a question about reviewing existing educational research related to designing experiential learning opportunities, specific to HSIs, asking, *"What existing theories and models can be used to design experiential learning within engineering HSIs?"*. In brief, multiple participants expressed an interest in performing literature reviews and exploring the status of practice-based pedagogies, suggesting a need for further communication of and participation in educational research applicable to HSIs.

Table I: Engineering curricula enhancement - A summary of coded responses, categories and examples of research questions articulated by ASEE workshop participants

Curriculum development strategies

Coded responses	**Research questions proposed**
Affordable active learning practices Application vs. memorization Hands-on activities Integrative course development Using disciplinary research to contextualize courses Project-based curriculum Teach experientially specific to HSIs	"What active learning practices are effective for HSI students and affordable for our institution? "What existing theories and models can be used to design experiential learning within engineering HSIs?" "What research has already been done regarding integration of disciplinary research at 2-year colleges?"

Multiple pathways to an engineering degree

Coded responses	**Research questions proposed**
Non-semester progress-based models Factors that lead to completion of degrees Student identifying pathways Role of two-year college Role of faculty support in articulation agreements	"Does starting at a two-year college with clearly defined articulation to a 4-year School increase student completion of degrees?" "Would it be possible to let go of the 4-year model with a view toward a progress-based (not time-based) model that has student achieve mastery over a longer period of time?" "What level of faculty support and maintenance of articulation agreements are needed to maintain success?"
Hidden curriculum	
Coded responses	**Research questions proposed**
Faculty-student relationships Equal opportunities Students understanding educational challenges Students' habits of mind	"How do we level the playing field for students at HSI versus students at other universities? (mainly due to work / job issues; hidden curriculum)" "What techniques did faculty adopt/develop to help change to develop students' habits of mind?"

Multiple pathways to an engineering degree

The second category within this research area referred to educators' interest in researching larger-systemic change by engaging with the existing structure of entry to engineering programs within HSIs. Analysis related to multiple pathways to an engineering degree included multiple participants proposing research into the role of two-year colleges, progress-based programs and addressing academic factors that lead to completion of degrees at HSIs. One participant framed their research question according to the clarity of the transfer process in enhancing completion of engineering degrees, *"Does starting at a two-year college with clearly defined articulation to a 4-year School increase student completion of degrees?"* This question builds upon existing research by [17] and [18] in their examination of the process of transfer students matriculating to an engineering specific bachelor's degree. As discussed in the paper, [17] proposes further research is necessary in communicating possible pathways to transfer students, as well as influencing existing institutional policies. Within our study, participants proposed further program change, with one participant driving toward non-semester-based engineering education by wondering, *"Would it be possible to let go of the 4-year model with a view toward a progress-based (not time-based) model that has student achieve mastery over a longer period of time?"* As highlighted in this quote, the focus on 'mastery,' and 'progress-based' learning pathways for students ties to language focused on competency-based education, a research area with limited literature, discussion and focus within HSIs.

Hidden curriculum

The third category that emerged is related to the concept of the hidden curriculum and its impact on Latinx students, an area with limited research in engineering education at HSIs. Educators expressed interest in exploring 'hidden' elements within engineering curricula important to student outcomes at HSIs, including the role of faculty-student relationships and students' understanding of educational challenges in comparison to high-school experience. Building upon existing definitions of the 'hidden curriculum' [19] expands that it represents "the unwritten, unofficial, and often unintended lessons, values, and perspectives made by individuals and found in physical spaces within an academic environment." Within their investigation, [19] explored and characterized the concept of the hidden curriculum within engineering education, revealing initial findings tied to the role of student and instructor interpersonal relationships, self-efficacy and self-advocacy within the classroom. From the ASEE workshop in this study, one participant referred to the hidden curriculum, wanting to compare opportunities for students at HSIs with other potentially predominantly white universities asking, *"How do we level the playing field for students at HSI versus students at other universities? (mainly due to work / job issues; hidden curriculum)."* Similar responses emerged from the data. In particular, another participant's research question referred to assessing students' understanding of educational challenges: *"Do the students understand education challenges at University level compared to high school?"* As a research question, understanding how students perceive educational challenges compared to their previous experience within formative education is a lens that potentially connects to the concept of the 'hidden curriculum' within the engineering classroom.

(2) Understanding Our Students

Throughout the data, participants focused on research interests that involved understanding, identifying and meeting the diverse academic and personal needs of the student population at HSIs. Two categories emerged as directions to better understand students: *meeting the needs of students with diverse abilities* and *faculty perceptions of students* [Tab. II].

Meeting the needs of students with diverse abilities

In meeting the diverse academic and personal needs of the student population at HSIs, educators indicated researching approaches to assess and respond to student preparation of prerequisites and the value of supplemental teaching. Coded responses referred to addressing skills like 'communication' or 'teamwork,' while a 'lack of preparation' in prerequisites and 'supplemental teaching' surfaced in multiple responses. One participant wanted to assess the role additional teaching guidance in improving student lack of necessary knowledge by proposing the research question: *"Can co-curriculum and supplemental teaching help in mitigating student deficiencies in lower division courses?".* This participant and others focused on exploring how to meet students' needs while they are in higher education and completing an engineering degree. For other participants, addressing specific student abilities was important in broadening participation across all engineering disciplines, (e.g., *"How does virtual reality promote the development of [spatial visualization abilities] (SVA)? How can the gap in SVA between female and male engineering students be decrease with explicit syllabi projects?"* and *"How can we improve language (especially writing) skills for all (incl. Native speakers of English) students?").* For these participants, their interest in examining student abilities builds upon existing research on spatial visualization abilities in engineering [20] [21] [22] and communication and language related skills, yet limited discussion has emerged from HSIs specific to engineering education.

Table II: **Understanding our students - A summary of coded responses, categories and examples of research questions articulated by ASEE workshop participants**
Meeting the needs of students with diverse abilities

Coded responses	Research questions proposed
Supplemental teaching mitigates student deficiencies Poor high-school preparation Limited preparation in mathematics Educational and professional competencies Spatial visualization abilities Communication skills Teamwork skills	"Can co-curriculum and supplemental teaching help in mitigating student deficiencies in lower division courses?' "How does virtual reality promote the development of SVA? Why is SVA a precursor of all disciplines in engineering? How can the gap in SVA between female and male engineering students be decrease with explicit syllabi projects?" "How can we improve language (especially writing) skills for all (incl. Native speakers of English) students?"

Faculty perception of students

Coded responses	Research questions proposed
Open-minded Hardworking Working alongside their education Limited knowledge of family support, values, demands. Family support critical to student success Limited knowledge of minority students	"What are faculty expectations of family support and family demands vs. reality of Latinx students?" "What were the greatest assets/strengths HSI students began with and ended with (are they different for HSI vs. non-HSI students?)"

Faculty perceptions of students

Participant responses encouraged exploration of the characteristics of students to better inform HSIs in their support of resources for students, including the leveraging of existing behavior, family values and work of Latinx students. Educators described students as hardworking, who often worked while studying in higher education. Multiple participants also expressed concerns about their limited knowledge about minority students and role of student family dynamics. For one participant, their interest was investigating the disconnect between faculty perceptions of Latinx student family values in relation to engagement with their education: *"What are faculty expectations of family support and family demands vs. reality of Latinx students?"* This concern is not surprising, as not all faculty at HSIs share their students' Latinx ethnicity [23] and must find alternative means of exploring the unique characteristics of their students. Being able to engage with students in this way and create an inclusive environment has been expressed by other researchers, e.g. [24]. A paper from the authors detailing the perspectives the educators in this workshop series held of their students discusses this [25].

(3) Faculty Development Relevant to HSIs

Participant responses that emerged connected to faculty development referred directly to the design of faculty development programs or resources specifically for HSIs, in the context of their institutional needs [Tab. III]. Coded responses included items like 'faculty development related to low-resource institutions,' 'funding for faculty to implement course changes' and 'faculty development to teach experientially' reflected and connected to similar research areas that emerged from the engineering curricula enhancement research area. Within this area, broader reflections on the development of faculty were proposed by several participants, aligned to the idea that faculty are the first line of care for students, and subsequently connecting the development of the faculty mindset and cross-institutional faculty collaboration.

Table III: **Faculty development relevant to HSIs - A summary of coded responses and examples of research questions articulated by ASEE workshop participants**	
Coded responses	**Research questions proposed**
Broadening faculty mindset and habits Faculty development related to low-resource institution needs Faculty development to teach experientially Faculty as first line of care Faculty skills gaps Funding for faculty to implement course changes Constraints working against faculty development Cross-institutional faculty collaboration	"What type of support for teaching faculty (seminars, TAs, etc) provide the best so that they can develop more integrative courses for better student outcomes." "How can the constraints working against working against faculty development be overcome to improve teaching and learning outcomes?" "[Could] significant interactions with faculty at other HSIs change faculty perceptions?"

(4) Perceptions of Instructional Faculty

This research area surfaced from a consistent participant response that explicitly referred to perceptions of instructional faculty [Tab. IV], expressing concerns about limited engineering education leadership opportunities for non-tenured faculty, and how curriculum development and teaching-focused positions are perceived as inferior by peers. A trend and concern observed by other researchers [26] [27]. As one participant asked, *"Why does the majority think teaching engineering is less than discipline-specific research?"* However, across multiple participant responses, additional perceptions of non-tenure track and instructional faculty emerged. Research areas that referred to non-tenure, teaching or instructional faculty, included coded responses like 'limited non-tenure engineering educational leadership opportunities,' 'teaching performed by non-tenure track faculty,' 'bringing together tenure/non-tenure faculty,' 'concerns choosing a non-tenure track position,' and 'perception of engineering education as less than research.'

Table IV: **Perceptions of instructional faculty - A summary of coded responses and examples of research questions articulated by ASEE workshop participants**	
Coded responses	**Research questions proposed**
Limited non-tenure engineering-education leadership Teaching performed by non-tenure track faculty Bringing together tenure/non-tenure faculty Concerns choosing a non-tenure track position Perception of engineering education as less than research	"Is choosing a non-tenure faculty position over a tenure-track render a PhD-holding engineer as inferior to engineering-related abilities?" "Why does the majority think teaching engineering is less than discipline-specific research?"

(5) Long-Term Impactful Approaches

This research theme reflects somewhat uncertain reflections about the concept of 'change' within HSIs, where multiple participants demonstrated broader apprehension about addressing specific research areas, in favor of investigating operational, practical, and sustainable approaches to areas like curricula development, institutional challenges, and student success [Tab. V]. Research areas that referred to this theme included coded responses like 'facilitating change and growth,' 'dealing with the challenges not addressed,' 'long-term impact to improve student success,' 'high-impact approaches for student outcomes,' 'recruit future engineering students,' and 'affective operational practices.'

***Table V:* Long-term impactful approaches - A summary of coded responses and examples of research questions articulated by ASEE workshop participants**

Coded responses	**Research questions proposed**
Facilitating change and growth Dealing with the challenges not addressed Long-term impact to improve student success High-impact approaches for student outcomes Recruit future engineering students Affective operational practices	"What specific practices have increase student recruitment and retention in engineering at other institutions (or within my Institution)?" "What department operational practices are effective in enabling HSI student success?"

Limitations

The study data was generated from a small participant sample, and focused on one particular handout, therefore the discussion of results was developed based on the premise of participants engaging with previous research to develop their own research question in context of their own institutional needs. However, these questions may not have emerged without engaging with the data from previous participants.

Implications and Potential Impact

This study was formed around a workshop which sought to co-develop research needs with engineering educators at HSIs through 1) reviewing existing research findings 2) iterating and adding to the preliminary results, and 3) generating initial research questions to pursue. Based on the distribution of the results to participants, our analysis, and discussion of the results, the authors anticipate the following developments and recommendations for further research.

Contribution to New NSF HSI Program

Through sharing conference information and preliminary results with other institutions that were awarded funds through the same NSF Dear Colleague Letter (DCL) [28] in June 2018, similar themes were emerging across the awardees' findings. Areas co-developed by awardees included 'faculty development', 'curriculum redesign or enhancement,' 'addressing student support needs' and 'establishing longitudinal designs to measure success.' These thematic groupings echo within the new HSI program, *Improving Undergraduate STEM Education: Hispanic-Serving Institutions (HSI Program)* [29] in particular, within the 'Building Capacity' category under the "Teaching and Learning in STEM" priority, promoting research that addresses curricular enhancement and faculty development.

Cross-Institutional Faculty Communication and Development

At the ASEE workshop, workshop attendees discussed and championed the opportunity of being able to learn from experiences with other faculty teaching at local HSIs, establishing potential collaborators within their own development in educational research and in their teaching practice. The findings of this study therefore brought attention to fostering further local educational development events across Hispanic Serving Institutions to amplify discussion from educators engaging in curricula change within engineering education. In specific, by supporting faculty to discuss and share existing interventions and results from HSIs, these discoveries may also prove generalizable to other educators at emerging HSIs. The findings also encourage shaping faculty development according to the assets that faculty have available to them, such as learning spaces, equipment and personnel. Furthermore, though recent studies on making the transfer process from two-year colleges to four-year colleges more transparent to institutional stakeholders (students, faculty, administration) [22] [23], our study suggests educators want to investigate and influence communication strategies between institutions, to increase completion of engineering degrees.

Engagement in Engineering Education Scholarship

At the ASEE workshop, at least ten attendees had not previously attended ASEE and had limited scholarly engagement in engineering education. As a result of the workshop, participants had the opportunity to engage with research ideas with and from other participants, which included establishing existing assets within their own institutions. Participants also developed research questions they wished to pursue, which as facilitators we were able to provide guidance and recommend ASEE conference sessions to attend related to their interests. In consequence, participants were exposed further to engineering education practice and research, with initial ideas and avenues to engage in scholarship of their practice. More broadly, this work helps focus engineering education research efforts that will have a lasting impact at HSIs, specifically by helping direct faculty embarking on research efforts towards impactful research questions.

Understanding and Addressing the Needs of Students

As a result of the design of the workshop, participants questioned the support needed for the student population at their institution, wanting to learn more about their students in order to appropriately design learning experiences for them. The research findings illuminated how faculty were interested in research and teaching approaches to understand and adapt to the needs of students. This included discovering more about their personal lives and family dynamics and address their own misconception about their students. Furthermore, raising awareness and investigating the role of instructional strategies that provide educators the opportunity to learn more about their students within their classes, may help shift misconceptions of students.

Conclusion

Latinx students are a growing population in engineering programs and Hispanic Serving Institutions (HSIs) are rallying to address their unique interests and needs. However, understanding what these needs are and how HSIs, particularly emerging HSIs, can support these students is lacking. This paper, therefore, summarizes the outcomes of a research initiation workshop series where 41 engineering educators from 17 HSIs and emerging HSIs convened to discuss the future of engineering education at HSIs. The qualitative analysis of artifacts from these workshops led to the articulation of five pertinent research areas: *Engineering curricula enhancement, Understanding our students, Faculty development relevant to HSIs, Perceptions of instructional faculty, Long-term impactful approaches.* By sharing these findings, this paper aims to support broader engagement in research and collaboration with and within HSIs, ultimately with a goal of increasing the representation of Latinx students in engineering.

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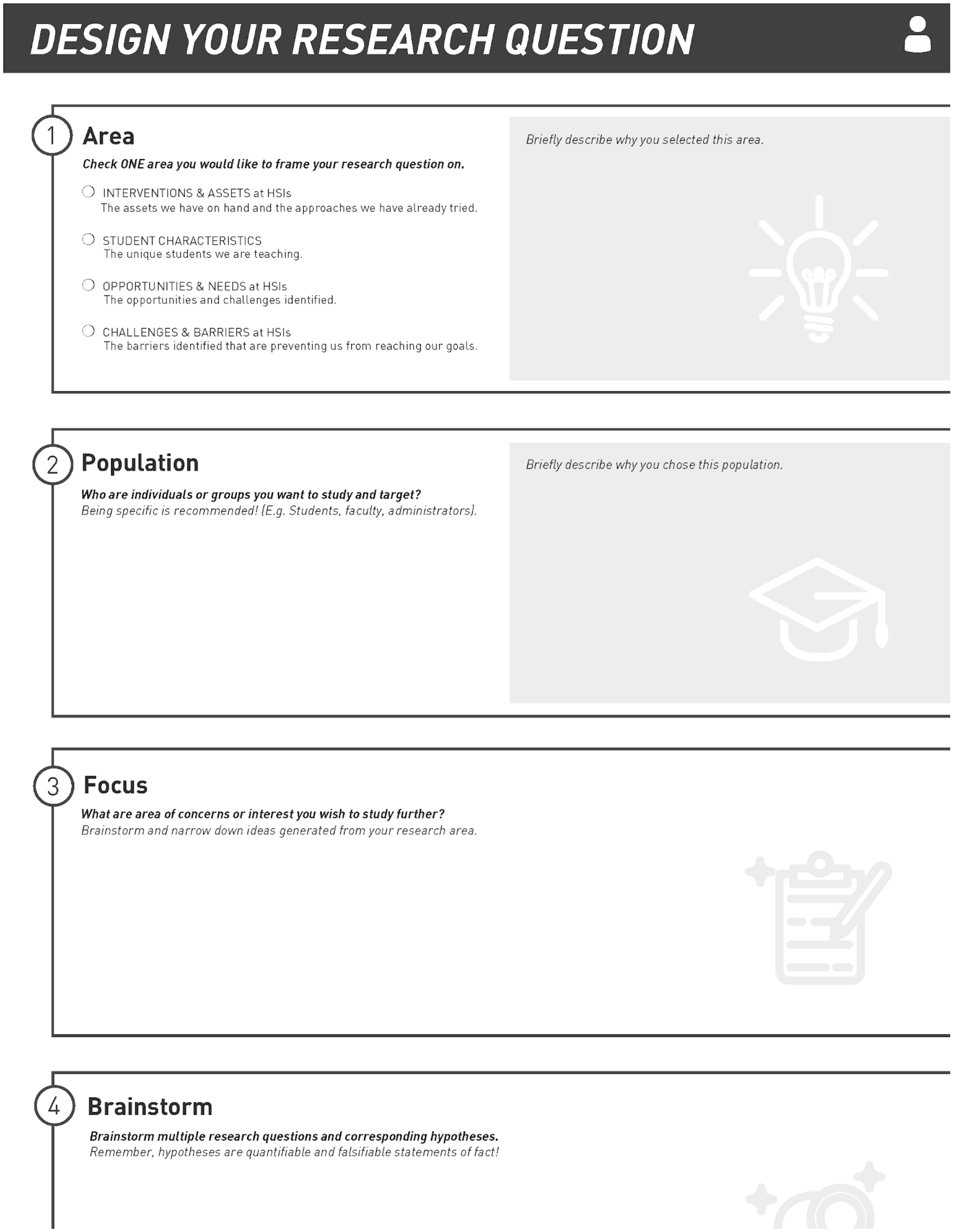
Appendix I

Image of 'Design your research question' activity handout used for data collection



DESIGN YOUR RESEARCH QUESTION

1 **Area**

Check ONE area you would like to frame your research question on.

- ❍ INTERVENTIONS & ASSETS at HSIs
  The assets we have on hand and the approaches we have already tried.
- ❍ STUDENT CHARACTERISTICS
  The unique students we are teaching.
- ❍ OPPORTUNITIES & NEEDS at HSIs
  The opportunities and challenges identified.
- ❍ CHALLENGES & BARRIERS at HSIs
  The barriers identified that are preventing us from reaching our goals.

Briefly describe why you selected this area.

2 **Population**

Who are individuals or groups you want to study and target?
Being specific is recommended! (E.g. Students, faculty, administrators).

Briefly describe why you chose this population.

3 **Focus**

What are area of concerns or interest you wish to study further?
Brainstorm and narrow down ideas generated from your research area.

4 **Brainstorm**

Brainstorm multiple research questions and corresponding hypotheses.
Remember, hypotheses are quantifiable and falsifiable statements of fact!