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# Development and Assessment of a Vignette Survey Instrument to Identify Responses due to Hidden Curriculum among Engineering Students and Faculty*

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One of the pivotal goals in engineering education is to broaden participation of different minorities. An overlooked barrier yet to be explored is how hidden curriculum and its connected constructs may impede this goal. Hidden curriculum (HC) refers to the unwritten, unofficial, and often unintended assumptions, lessons, values, beliefs, attitudes, and perspectives in engineering. This paper will present the development and assessment of a mixed-method vignette survey instrument to evaluate the responses of current engineering students and faculty when exposed to several examples of hidden curriculum. Results from 153 engineering students and faculty across the United States and Puerto Rico were used to assess the survey sub-subscales (HC awareness, emotions, self-efficacy, and self-advocacy). Findings revealed Cronbach alpha coefficients of 0.70 (HC awareness), 0.73 (emotions), 0.91 (self-efficacy), and 0.91 (self-advocacy). The overall instrument had a reliability of 0.74. Alongside HC awareness, we found that among different axes of inequity, gender, role, and institution type are important elements that shaped the responses of these engineering populations.

**Keywords:** hidden curriculum; engineering; mixed-methods; vignette; survey; faculty; students

## 1. Introduction

The aim of this work is to present the development and assessment of the quantitative portion of a mixed-methods vignette survey instrument designed to explore students' and faculties' responses to hidden curriculum (HC) in engineering. Hidden curriculum refers to the unwritten, unofficial, and oftentimes unintended, assumptions, lessons, values, beliefs, attitudes, and perspectives that are not openly acknowledged in a given environment [1–7]. Depending on the types of HC messages present, an individual can interpret these messages as being positive or negative. In turn, internalization of these messages can lead to decisions and actions that can encourage or discourage diverse individuals from persisting in their academic environment [7, 8]. For example, for minoritized K-16 students, literature suggests that HC is primarily linked to negative and invisible messages regarding students' performance ability in their courses [9–22]. Negative messages such as these could result in undesired consequences (e.g., drop-out) [23].

While HC has been normally linked to negative outcomes, there is a body of literature that suggests that success for minoritized groups can be promoted by early exposure of HC to institutional [2], social [8, 20, 24, 25], and cultural capital [2, 8, 14, 18, 20] in their education. Studies aimed at uncovering HC have been explored in fields such as education, psychology, business, and medicine and have shown an overall discourse between students' and educators' values and beliefs related to their profession [8, 10, 14, 18, 24, 25] and around mentoring [20]. Most science, technology, engineering, and mathematics (STEM) studies on HC have focused on exploring gender expectations in syllabi [26], minorities' access to courses [27], and gender inequality in STEM [28]. In engineering, HC-type work has primarily focused on gender roles in engineering and ethics reform [8, 26–29, 30]. Yet, no studies have explored in detail how individuals in engineering respond when HC is revealed to them [4–7].

HC is traditionally explored qualitatively (e.g., ethnography) [14, 18] since it poses a powerful way

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to bring out the voices of the marginalized. However, recent literature around policy are calling researchers for richer explorations of this complex phenomenon (i.e., issues of diversity and inclusion) through both a quantitative and qualitative lens [31–33]. This manuscript describes the process undergone by the research team to develop and assess the first convergent, mixed-methods vignette survey instrument to explore responses from engineering students and faculty to HC and its connected constructs.

This manuscript includes a discussion of the considerations and decisions the authors made when developing this convergent mixed-method (integrates both qualitative and quantitative elements cohesively; [46]) instrument to study HC responses among engineering groups. Second, validation and reliability assessment of the instrument through exploratory factor analysis and other statistical analysis was explained. Third, the manuscript includes a discussion and implication section for individuals involved in engineering education.

## 2. Literature Review

### *2.1 Hidden Curriculum in Engineering: The Need for Mixed-Method Instruments*

Within educational and professional environments and settings, individuals don't just learn "what is formally being presented . . . but also accumulate other hidden lessons in the process" [6, p. 1]. Hidden curriculum, as one of four primary forms of curriculum [4, 6, 7], lies in the liminal spaces of the conscious and unconscious mind to inform an individual about their surroundings. For example, if the majority of courses in a four-year degree program are exam-based and a student participates in a handful of project-based courses during their undergraduate education, the student may interpret that their future profession will prioritize an individual's technical merits and abilities over teamwork; this assumption may not parallel what industry requires of their graduates. These distinctions are important to uncover as they can help scholars, educators, and administrators better understand how students are navigating formalized educational structures in fields like engineering, which are typically described as meritocratic [34], hegemonic [35, 36], male-dominated [37-40], and unchanging [41].

While HC has been explored in fields like medicine [42, 43], education [44, 45], and sociology [29, 45], its exploration in engineering is still fairly new [4–7]. Most research in hidden curriculum up to this point has been done primarily from a qualitative perspective [8, 11, 14, 15, 18, 20, 24–26, 31]. While voices are indeed elevated for participants using qualitative approaches, the depth of data required from a small number of participants, may limit the "power in numbers" outcome that could influence large-scale policy changes and other campus-wide reforms [32].

To our understanding, no one has attempted to develop a scholarly understanding of HC from a response pathway standpoint, encompassing: (1) whether HC is recognized (HC awareness); (2) the way HC is recognized (e.g., via emotions); (3) whether HC recognition leads to discriminant motivations in the individual (i.e., self-efficacy); and (4) how HC recognition may influence a person's willingness to take an action (i.e., self-advocacy).

### *2.2 HC Responses in Engineering: The Beginnings of a Conceptual Model*

The way that an educator chooses to communicate curriculum or course content to their students, either consciously or unconsciously, can result in lessons that a student takes away with them even after the completion of a course. The intentionality (i.e., intentional or unintentional) and the transmission (i.e., implicit or explicit) of that communication can fall into four categories of curriculum as summarized in Fig. 1. Formal curriculum (an explicit, intentional form of transmission) consists of expectations communicated primarily in written form to evaluate the quality of a product (e.g., homework) as well as student performance (e.g., exams) [6, 14, 15]. Informal curriculum (an implicit, intentional form of transmission) involves learning through personal interactions (e.g., student-to-teacher, student-to-student) [6, 14, 15]. Null curriculum includes those elements or topics that may not be covered in a class due to "regulations from higher authorities, lack of comfort-level from a teacher to discuss a given topic (e.g., politics), or the controversial nature of the topic" [6, p. 1]. Hidden curriculum is in between different forms of transmission and intentionalities [6]. For example, the transmission of HC can occur implicitly and unintentionally [6]. On the other hand, as previously proposed [6], HC transmission can also occur through explicit ways and intentionally, at least in fields like engineering. These HC "life lessons" may or may not necessarily tie to the formal, informal, or null curriculum types.

To explore responses to HC, in other words, how individuals recognize, react to, and respond to HC, the authors conducted an initial study [4] that suggested that individuals can respond to HC through 16 or more distinct factors, although four of them appeared more prevalent: (a) HC awareness; (b) emotions; (c) self-efficacy; and (d) self-advocacy.

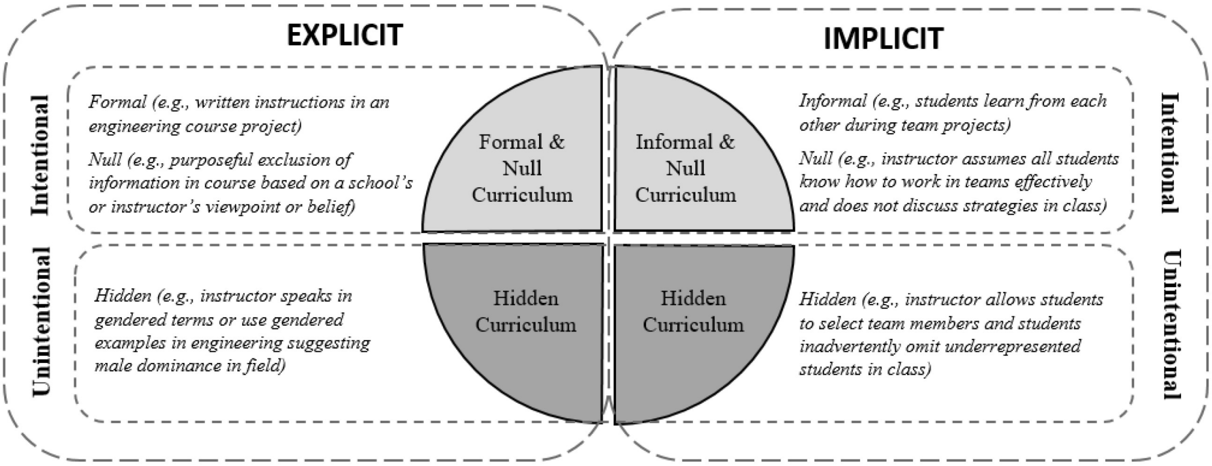


**Fig. 1.** Four types of curriculum.

### *2.2.1 HC Awareness, a Recognition Response*

An individual's self-awareness to the presence of HC, or *HC awareness* (HCA), is an important step in recognizing and discerning what and how information is being communicated [6]. Recent advances in social and cognitive psychology, particularly in the area of metacognition (i.e., an individual's belief about their mental state) [47] has expanded our understanding about what is considered conscious and what constitutes awareness [48]. The term 'conscious' generally refers to a person directly *seeing*, *knowing*, or *feeling* a particular mental content rather than having to indirectly infer it [48, 49]. Awareness is a sub-component of consciousness where an individual recollects internally an experience, discriminates the experience, and represents it externally (e.g., verbalization; [50, 51]). Depending on the situation present, an individual can move into the realm of what is not cognizant (unconscious) or what is misrepresented (meta-consciousness) [48, 52]. Regardless of the level of awareness a person may have about an issue, these can't be brought up to full consciousness unless they are internalized first.

In engineering, there are limited publications regarding examples of hidden curriculum [4–7] although plenty of examples can be found in fields like education, medicine, and sociology [29, 42–45]. Representative samples of hidden curriculum across some of these disciplines are summarized in Table 1.

### *2.2.2 Emotions to Process HC Awareness*

Internalization of an experience typically occurs through an individual's emotions (EM). Emotions assist humans to narrow down variables that are important when making decisions [53] and process learning and socialization [53]. Emotions also serve to explore the influences that several forms of subliminal and excitatory stimuli can have on social behaviors [52]. In academic settings, emotions consist of many coordinated processes that involve affective, cognitive, motivational, expressive, and peripheral subsystems that are intertwined [53]. Emotions can be manifested in two forms: (a) valence (positive or negative emotions) or (b) activation (focused or unfocused energy). Positively activated emotions (e.g., enjoyment) may increase reflective processes [53] whereas negatively activated emotions (e.g., anger) may result in low levels of cognitive processing [53]. Emotions contribute to how a person learns, perceives, decides, responds, and problem solves [53].

In the context of HC, emotions can help signal to a person how external expressions, glances, gestures, and other behaviors influence that person's state of being [4, 54, 55]. In engineering, in the context of HC and emotions, the authors are the only ones, to date, exploring these constructs together [54–56]. As a result, to illustrate how emotions are involved when individuals process their awareness to a HC, the authors opted to present some *raw, denaturalized* quotes from participants who responded to the qualitative emotions questions in this survey; all emotion-related terms or phrases have been bolded.

> "I feel so **angry** and so **frustrated** when I really knew something, and I proved it in many ways, but if I failed the [engineering] test it means that I'm not good, or able to became an engineer. On the other side, I experienced **rejection** for being a woman engineering student. The last one just made me feel **proud** of me and pushed me to be the best in what I do and prove that a woman is capable to be an engineer." (Undergraduate Engineering Student, Woman, Latina, Hispanic Serving Institution, Entry 13).

> "I am a smart person of Pacific Islander background. I acknowledge that I'm not the smartest person in the room, but that doesn't stop me from pursuing my **passion** in engineering. I know that in general, Pacific

**Table 1.** Some hidden curriculum examples across different disciplines but primarily in engineering

| Source and Example Quote |
|---|
| (Higher Education)<br>"In discussions with a foreign female mentor, this student expresses to her that she does not want to go to the professor because she is 'not a good writer' and because she is 'not comfortable with talking with people in such high authority'. The student indicates that she prefers to have other individuals proofread her assignment rather than going to the professor for help. The mentor tries to dissuade her by indicating that in order to succeed in college she has to 'follow the rule of higher education and that **one of the rules** is that **you are expected** to reach out and ask for help when you need it' " [20, p. 24] |
| (Medicine)<br>"You're attending talks about the patient's diagnosis and poor prognosis to the ward team in front of the patient and **without including** the patient in the conversation or asking if he has any questions." [42, p. 55] |
| (Engineering)<br>"Professional dress was one area where women found they did not fit perceptions about engineering. Design class students **were expected** to wear professional dress when they met with clients and for formal presentations to faculty and other design teams. The sophomore class professor gave these instructions: 'You should be at least as formal as the client. If he has a coat and tie, you keep your coat on. If he is in a shirt and tie, you can take off your jacket.' This **posed dilemmas** for women **that did not exist** for men." [8, p. 163–164] |
| (Engineering)<br>"On the surface, formal lines of communication, such as orientations, graduate advisors and handbooks purporting to facilitate women becoming graduate students are not always reliable. The alternative, which **no one explicitly states**, is to engage in the informal track through establishing social networks and building social capital (*an example of hidden curriculum*). None of the women mention hearing how important this is to their graduate careers. Graduate student subculture is certainly important, but this study suggests that women in engineering are at a disadvantage due to their low numbers, the low numbers of women faculty, and **assumptions of traditionally gendered** divisions of labor in the home." [29, p. 145] |
| (Engineering)<br>". . . faculty commented that a **professional expectation** is to 'not ask many questions' (Respondent 19, Full Professor, Tier 1, Female, White) and 'not create any problems' (Respondent 5, Associate Professor, Tier 5, Male, Hispanic) and that ' '**mantras** such as 'engineers provide solutions, not problems' ' (Respondent 33, Full Professor, Tier 5, Female, White) are **valued more** among engineering departments." [5, p. 14] |

Islanders do not choose this career choice. It **frustrates** me when others judge me and look down on me because of these two characteristics. I'm **proud** to be who I am and I believe I can have a positive influence in this field. I'm not looking for a **pity** party, I know who I am and I am okay with it. I have surrounded myself with good people who help **support and lift me when things get tough**." (Graduate Student, Man, Pacific Islander, Predominantly White Institution, Entry 72)

"An engineering professor who always begins his courses by telling students that if they are interested in the arts that are going to 'play guitar under a tree or make drawings' and abandon the engineering career, because they are not made for that career. I felt **frustrated** and **upset."** (Undergraduate Engineering Student, Man, Latino, Hispanic Serving Institution, Entry 131).

### 2.2.3 *Self-efficacy Regulates Emotions*

At the same time, these emotions cannot occur unless a person *believes* that they are able to experience or allow oneself to experience emotions such as joy, anger, and pride [57]. Thus, self-efficacy (SE), or an individual's belief on their ability to ameliorate adverse states [58] may serve to discern and regulate these emotions. Very early work from the group is beginning to suggest that faculty and students express nearly opposite self-efficacies when it comes to recognizing hidden curriculum, where higher self-efficacies among faculty do not necessarily parallel to their level of awareness about HC [6] and the valence of those connected emotions [53, 57]. In engineering, in the context of HC and self-efficacy, the authors are the only ones, to date, exploring these constructs together [54]. As such, to illustrate how is self-efficacy involved when individuals become aware of HC, the authors opted to present some *raw, denaturalized* quotes from participants who responded to the qualitative self-efficacy questions in this survey; all self-efficacy-related terms or phrases have been bolded.

"I **overcame** successfully in engineering a class that the professor said that almost no one was gonna passed his class, and with that in mind, I **did it besides of what he said**." (Undergraduate Engineering Student, Man, Latino, Hispanic Serving Institution, Entry 5)

"I'm afraid to speak in front of people. My family and I moved from China back in high school. I had a very bad English base. That caused me to not make much friends back then, and developed a habit of being afraid to talk to people. That still bothered me when I entered university. After I picked my engineering major, I grouped with people with similar habits that opened me quite a bit. Also, we had multiple speeches and opportunities to talk in front of people. **Now, I have changed**." (Undergraduate Engineering Student, Man, Chinese, Hispanic Serving Institution, Entry 30)

"[. . .] the teacher told me to quit but I went to another professor who is pro-students and asked for help in some topics. I practiced, saw everything in **my own perspective** and passed the class." (Undergraduate Engineering Student, Woman, Latina, Hispanic Serving Institution, Entry 140)

### 2.2.4 *Self-advocacy is Sustained and Reinforced through an Individual's Self-efficacy*

In turn, self-efficacy influences how an individual takes control over their own motivation, behavior, and social environment [57, 58]. Self-efficacy, in the form of confidence, can ignite subsequent actions such as *self-advocacy* (SA) or an indication of a person's willingness to take action and speak up about a matter to improve their quality of life [59]. Early work from our research group is beginning to suggest that at least among graduate students in engineering, "awareness of HC or related issues was seen as the first step of taking action to advocate, caring about the issue was necessary, and having an emotional reaction served as an igniting force to spark an action. However, these were not enough to resist negative messages associated with HC. . . it is a sustaining reinforcement" [7, p. 11]. This suggests that self-advocacy in isolation cannot ignite change but rather is a connected pathway needed to encourage an action. In engineering, in the context of HC and self-advocacy, the authors are the only ones, to date, exploring these constructs together [7, 55]. As such, to illustrate how self-advocacy may surface as a result of HC awareness, the authors opted to present some *raw, denaturalized* quotes from participants who responded to the qualitative emotions questions in this survey; all self-advocacy-related terms or phrases have been bolded.

> "I have **advocated for myself** by joining organizations that are catered to my background [. . .] I was influenced by seeing other people succeed in these organizations." (Undergraduate Engineering Student, Woman, Latina, Hispanic Serving Institution, Entry 11)

> "[. . .] I have always found relief and **potential changes** on difficult situations by **making professors know how I feel and what things should be changed**. A factor that influences my self-advocacy is the feeling of underestimation of my capabilities from my surroundings." (Undergraduate Engineering Student, Man, Latino, Hispanic Serving Institution, Entry 116)

> "When I faced HC, either in the classroom or in professional development associations (which is also where I'm coming to terms with the fact it exists), I **spoke up**. I **researched** who the key players in the association or classroom were in order for a change to happen and we **developed a plan** to change or **bring up** particular topics." (Adjunct Faculty, Woman, Latina, Hispanic Serving Institution, Entry 152)

### *2.2.5 Integrating the Four Responses of HC*

Together, these four constructs can serve as a guide to understand more holistically hidden curriculum, as suggested in Fig. 2.

## 3. Methods

### *3.1 Research Design*

The entire research is centered around a complex, mixed-method experimental intervention design, where qualitative and quantitative data collection and analysis can be merged in a convergent form (Fig. 3; [46]). As suggested by Bryman [60], integrating qualitative and quantitative research can occur during validation, data collection, analysis, and interpretation stages. For this study, whose focus is to present the development and assessment of the instrument, we will focus primarily on the quantitative (denoted as QUAN) elements of the instrument, although it is our position that both qualitative (QUAL) and QUAN hold equal weight, particularly towards informing future interventions.

### *3.2 Hypothesis*

Since engineering students' and faculties' attitudes and other attributes may be important in determining HC pathways and because there is no existing HC in engineering instrument, we sought to develop an instrument specifically designed for all engineering populations regardless of demographics or institutional type/region. For this purpose, for a period of a year and a half, we underwent 2 advisory board/consultant meetings, several research group meetings, and 8 administered trials of the survey iterations from diverse gender, races,

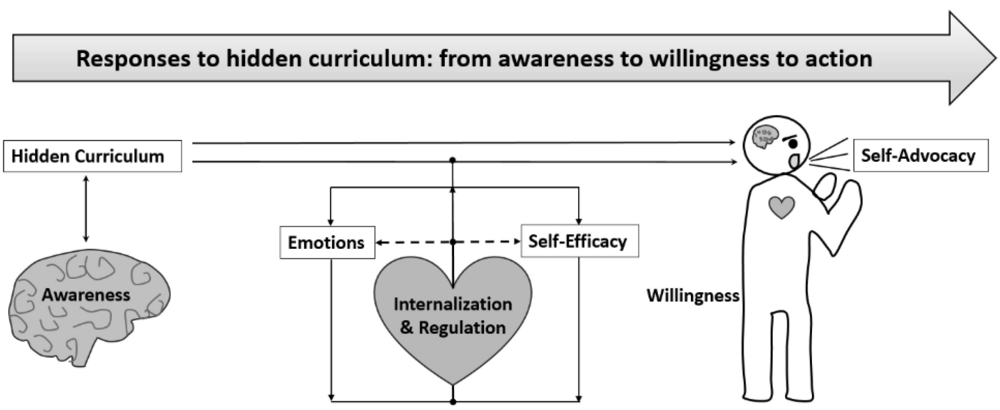


**Fig. 2.** Schematic representation of individual responses to hidden curriculum.

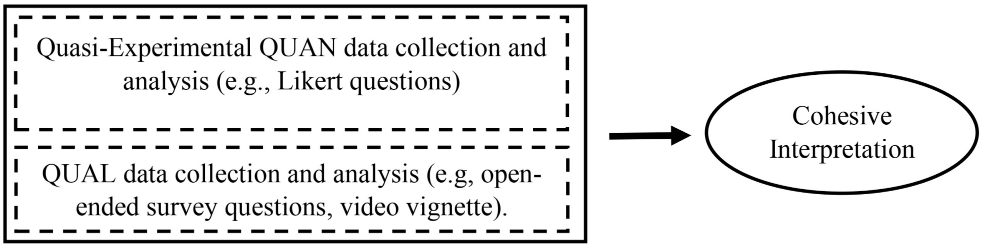


**Fig. 3.** A modified schematic diagram representing the development of the HC instrument using a complex, mixed-method experimental intervention as described by Creswell & Plano Clark [46, p. 105].

and ethnicities throughout the U.S., prior to disseminating the final instrument version presented in this paper. The resulting data allowed us to explore the psychometric properties of the item scales to address the dimensionality of each attribute, the items that do not address the attribute or belong to the item set, the reliability of the scales, and the validity of the measure of each associated attribute.

### *3.3 Research Participants*

Our participants for the final version of the instrument represent 153 of the engineering students and faculty from across the United States (US) and Puerto Rico (PR). The demographic breakdown of the participants is found in Table 2. Since HC is a phenomenon that is primarily tied to underrepresentation in fields like medicine and education [24, 25], the authors were intentional of increasing the voices of minoritized groups in engineering to the best extent possible. We also were intentional at elevating the Latinx (a gender-neutral term for individuals of Latin descent; [61]) voice given that the ultimate goal of this work is to develop an advocacy mentoring model for these minoritized groups in engineering [62].

**Table 2.** Self-Identified Participant Demographics (n = 153)

| | | |
|---|---|---|
| Role | Undergraduate Student | 71% |
| | Graduate Student | 10% |
| | Faculty (Tenure-Track) | 4% |
| | Other (e.g., Adjunct) | 15% |
| Gender | Women | 33% |
| | Men | 67% |
| Citizenship | Domestic | 87% |
| | International | 13% |
| Race/ Ethnicity | Asian | 4% |
| | Black | 2% |
| | Latinx | 61% |
| | White | 24% |
| | Mixed Race | 9% |
| First Generation | Yes | 22% |
| | No | 76% |
| | Not Sure | 2% |
| Non-traditional | Yes | 28% |
| | No | 68% |
| | Not Sure | 4% |
| Institution Type | Hispanic Serving | 77% |
| | Primarily White | 22% |
| | Other (unstated) | 1% |

### *3.4 Instrument*

#### *3.4.1 Rationale for Development and Design*

The developed instrument consists of open-ended questions, Likert-scale items, and a video vignette (that served as an elicitation prompt) as recommended by Finch [63]. The development and assessment of this survey is summarized in the subsections below.

#### *3.4.2 Selection of the Type of Instrument and Placement of Items*

Due to the complex and potentially fragile nature of this topic, a vignette approach was deemed appropriate [4]. Vignette surveys are traditionally used by sociologists to explore participants' attitudes, perceptions, beliefs, and values [63] to hypothetical scenarios containing "difficult topics of enquiry" among participants [64, p. 384]. Vignettes are also starting to be used in engineering education research [7, 65, 66]. In these vignettes, participants can respond to a familiar contextual situation by commenting on what a fictional character in the vignette should do without necessarily asking the participants what they would personally do if placed in that same situation [63]. In this way, researchers frame HC for the participants. Furthermore, the authors considered that since engineering is known to be hyper-rational [67, 68], it is possible that HC may not be easily recognized [4]. This consideration has been confirmed in earlier trials of this instrument [4–7, 59].

As such, it was important that elicitation techniques such as videos were integrated into the mixed-method instrument to help participants "see and feel HC rather than read about it" [4, p. 7]. Via video and image elicitation, the authors weaved qualitative questions into the instrument to provide participants with the opportunity to comment on the video scenes and at the same time reflect on their own experiences [69–72]. For this study, video vignettes were purposely placed after the HC statements but before the EM, SE, and SA sub-scales. This placement would allow the video vignette to serve as a point of recognition and reflection between the HC statements and the visuals in the video to minimize any potential "mental shortcuts" that participants could use to make sense of a new concept or phenomenon [73, p. 4]. Also, since framing has an influence over the interpretation of meanings and its connections to ideas and beliefs [73], the research team wanted to make sure its placement would minimize potential variations in participants' understanding of this phenomenon.

Following this video vignette placement, the emotion questions followed. Since HCA relies on the recognition of the "unstated norms, values, and beliefs embedded in and transmitted through the underlying rules that structure the routines and social relationships in school and classroom life" [1, p. 47], most individuals fundamentally cannot evaluate any environment without feeling it first [74]. On the other hand, it is unlikely that a person can effectively express or manage their emotions if they do not believe themselves capable to do so [4, 54]. As such, self-efficacy items on the survey followed the emotions questions. Finally, the self-advocacy questions followed since a willingness to enact an action first requires an emotional and self-efficacy internalization of the phenomenon [4, 54, 75]. The order of the instrument items and the Likert scales are summarized in Tables 3 and 4.

### *3.4.3 Video Vignette Development*

One unique element of the instrument is the inclusion of a custom-developed video vignette to serve as a prompt for participants to react upon and better understand hidden curriculum. These hypothetical video scenarios were developed after completing a review of the engineering and higher education literature through a web search of phrases like "hidden curriculum", "implicit", "chilly climate", "expectations", "norms", "minoritized", "minorities", "higher education", "diversity", "engineering", and "STEM". The review included the following list of journals: *Journal of Engineering Education*, *American Society of Engineering Education*, *International Journal of Engineering Education*, *Journal of Women and Minorities in Science and Engineering*, *Medical Education*, *International Journal of Management Education*, as well as textbooks, dissertations, conference proceedings, and published studies relating to HC (e.g., [8, 20, 29]).

From this search, sample scenarios were written in the form of a screenplay [4] and shared with a panel of six researchers (i.e., graduate students, junior and senior faculty): four researchers in engineering education, one researcher in sociology, and one researcher in curriculum and instruction. From this, a draft script was revised and shared with a new group of engineers and engineering educators, all from minoritized groups, for com-

**Table 3.** Description and order of the entire mixed-method instrument

| Survey Section | Description | Type of Questions |
|---|---|---|
| (1) Raw Engineering Perceptions | Participants were asked to provide their raw perceptions about engineering and who belongs in engineering. These questions were asked before any definition of HC was provided to them. | QUAL |
| (2) Hidden Curriculum Awareness | Participants were given a written definition of HC followed by six HC statements (refer to Table 3). Participants were asked whether they agreed or disagreed on the 'trueness' of the HC statement provided in the context of engineering. | QUAN & QUAL |
| (3) Video Vignette | Participants were asked to watch a 7.5-minute video, which highlighted several examples of HC involving a minoritized Latino student and Latina faculty. Participants were then asked to define HC in their own words and provide personal examples of HC in engineering. | QUAL |
| (4) Emotions | Participants were asked to select an emotion they felt corresponded to the six HC statements and whether the emotion felt was positive or negative. They were also asked to recall a personal experience with HC and the emotions they experienced in that situation. | QUAN & QUAL |
| (7) Self-Efficacy | Participants were asked to select their perceived level of self-efficacy in succeeding in engineering if they experienced HC in their education. They were also asked to describe an obstacle they have had to overcome in engineering. | QUAN & QUAL |
| (8) Self-Advocacy | Participants were given a definition of self-advocacy and asked to identify their willingness to ignite an action on behalf of themselves and others around issues of HC. They were asked to provide a personal example highlighting what they have self-advocated for in engineering. | QUAN & QUAL |
| (9) Wrap-Up | These questions inquired about the major lessons learned about HC through this survey and asked participants to reflect on their major passions for pursuing a degree in engineering. | QUAL |
| (10) Demographics | Participants were asked to enter information about their axes of inequity such as age, role (student versus faculty), university of study or employment, race, gender, ethnicity, and first-generation status. | QUAL |

**Table 4.** Description of the statements and descriptions used for the QUAN elements of the instrument

| **Statement Number** | **Description** | |
|---|---|---|
| 1 | The assumption that *not everyone has the same level of access to resources to become an engineer.* | |
| 2 | The assumption that *the central focus of engineering is on the technical specifications of the product rather than socio-cultural considerations.* | |
| 3 | The assumption that *students who do poorly in an undergraduate engineering course usually change to a non-engineering major.* | |
| 4 | The assumption that *women in engineering are an exception and not the norm.* | |
| 5 | The assumption that *in engineering "soft skills" (e.g., communication, teamwork) are under-valued.* | |
| 6 | The assumption that *diversity in engineering is under-valued* | |
| **Sub-Scales** | **Description** | **Likert-Scale Options** |
| Hidden Curriculum Awareness | Hidden curriculum (HC) refers to unwritten, unofficial, and often unintended assumptions, lessons, values, beliefs, attitudes, and perspectives that are not openly acknowledged in a given environment. We developed some HC assumptions for engineering. Read each statement carefully. Do you believe these assumptions exist? | '1' – Definitely Not<br>'2' – Probably Not<br>'3' – Possibly<br>'4' – Very Probably<br>'5' – Definitely Yes |
| Emotions | Emotion is an individual state caused by an experience, thought, expression, impulse, or reaction to a circumstance. Read each HC assumption carefully. Indicate the main emotion you experienced when you read each statement. For each emotion selected, on a scale of 1–5, rate if the emotion was positive or negative to you. | '1'– Very Negative<br>'2' – Fairly Negative<br>'3' – Neutral<br>'4' – Fairly Positive<br>'5' – Very Positive |
| Self-efficacy | Self-efficacy is your belief in your ability to succeed in specific situations or accomplish a task. On a scale of 1-5, how much do you believe you can succeed in your engineering path if the following HC assumptions were present at your university? | '1' – Definitely Not<br>'2' – Probably Not<br>'3' – Possibly<br>'4' – Very Probably<br>'5' – Definitely |
| Self-Advocacy | Self-advocacy is the willingness to speak or act on your own behalf to improve your quality of life, effect personal change, or correct inequalities. On a scale of 1-5, rate how willing you are to speak or act on your own behalf to change these HC assumptions in your engineering path? | '1' – Not Willing<br>'2' – Slightly Willing<br>'3' – Moderately Willing<br>'4' – Very Willing<br>'5'– Extremely Willing |

ment. The screenplay was further revised and shared with a group of professional screenwriters. Edits were subsequently made to the screenplay and shared once more to another group of engineering educators and educational consultants for comments. Final edits occurred between the first author, the professional screen writer/videographer, and actors hired for this work. The video was created at the former home institution of the first author and editing of the video resulted in a ~7.5 minute video-recorded vignette, in high definition-grade quality, split into two parallel scenes.

The video starts with a White male engineering full professor (Dr. Brown) and a Latina engineering assistant professor (Dr. Garcia) while working in their respective offices in preparation for an introductory engineering course. Dr. Garcia and Dr. Brown teach two sections of the undergraduate course, in which the full professor is the lead instructor. During a casual interaction in a university hallway, the instructors discuss the possibility of mentioning contributions of Latinx engineers to their class considering that their institution had recently announced its support of Hispanic Heritage Month. The scene moves to the classrooms where viewers witness the interactions between the undergraduates Shane and Luis with Dr. Brown and the undergraduate Brian, with Dr. Garcia. Brian and Shane are White and male undergraduate engineering students while Luis is a Latino male engineering student. A more detailed description of the characters and scenes can be found in prior publications from the research team [7] and in Fig. 4.

### *3.4.4 Naming Considerations*

Even though considerations of naming an instrument are traditionally not covered in survey research [76, 77], given the complex and proposed potential intertwined pathways of HC, it was important for the research team to discuss the naming at length. It was decided that the team would rely on Harper's recommendations to the framing of anti-deficit research questions and studies [78] and recognized that "while there have been multiple meanings of the term hidden curriculum, the study of hidden curriculum has been defined by a unitary goal which is to make explicit and visible that which was formerly invisible" [79, p. 1]. As such, the research team conducted an in vivo-coding analysis among early participants of the first trial of the survey and codes such as "competing priorities", "messages", "uncovering", and "confusing expectations" were identified. From these early codes, a survey name was derived:

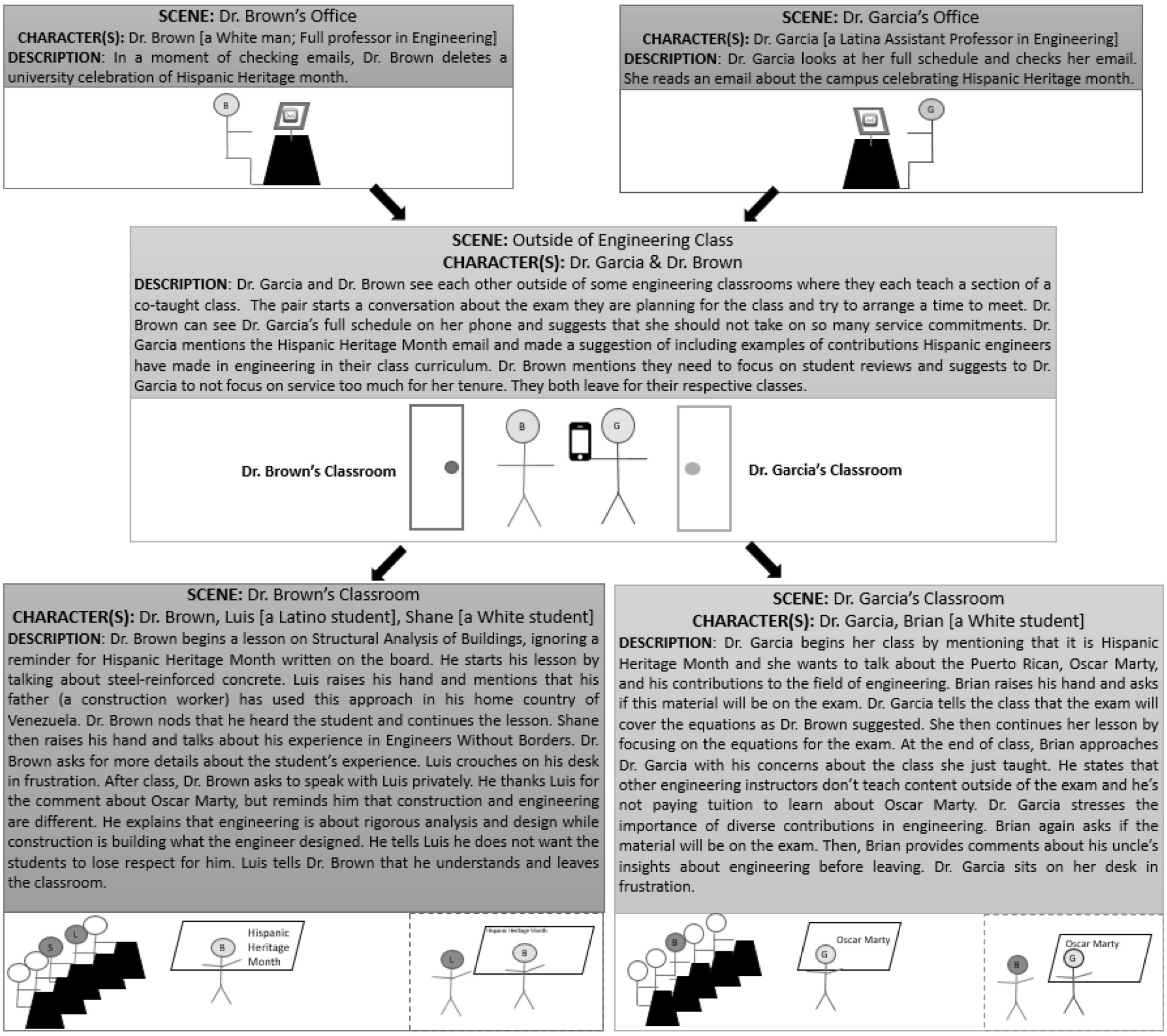


**Fig. 4.** Pictoric depiction of the vignette video scenes in the hidden curriculum survey instrument.

UPHEME (**U**ncovering **P**reviously **H**idden **E**ngineering **M**essages for **E**mpowerment), which when used as the word "upheme" (pronounced as *uph hēm*) represents Old English definitions of "upend" and "overturn" [80]. The UPHEME instrument will be referred to in this way for the duration of the manuscript.

### *3.5 Recruitment and Administration Procedure*

The participants represented in this manuscript were recruited through a series of gatekeeper faculty and leaders in engineering professional societies and institutions of higher education (both research- and teaching-intensive) in the US and PR via email. The email included the Institutional Review Board-approved letter of information, a representative flyer they could print for recruitment purposes, and the online survey link. The survey took on average approximately 20 minutes to complete. All participants that fully completed the survey also received a $20 Amazon gift card within 7–10 business days of completing the instrument.

### *3.6 Validity and Reliability*

Content validity was addressed throughout the year-and-a-half instrument development process, the survey trials, and by iterative development and refinement of each instrument item throughout the trials. Also, construct validity was established by factor loading analysis through eigenvalues to determine whether all items in the sub-scales were associated with the attribute of interest. Factor loadings that are lower than an absolute value of 0.40 may indicated a need to discard or revise a particular item in the instrument [81].

Reliability of the instrument was analyzed through Cronbach alpha coefficients, which measures the internal consistency, during the survey development of its four constructs (HC awareness,

**Table 5.** Principal component analysis with varimax rotation using Kaiser normalization of the four factors (HC awareness, emotions, self-efficacy, and self-advocacy) for the UPHEME instrument; bolded values represents a factor loading of above 0.40, indicating a moderate-to-strong correlation between the variable and the factor.

| | Factor Loading | | | |
|---|---|---|---|---|
| **Variables** | **HCA** | **EM** | **SE** | **SA** |
| Statement 1 *(Access to resources in engineering)* | **0.76** | **0.79** | **0.89** | **0.87** |
| Statement 2 *(Priority over technical aspects of engineering)* | **0.68** | **0.73** | **0.87** | **0.84** |
| Statement 3 *(Poor performers in engineering leave)* | **0.67** | **0.72** | **0.84** | **0.83** |
| Statement 4 *(Women in engineering are an exception)* | **0.56** | **0.62** | **0.81** | **0.81** |
| Statement 5 *(Soft skills are undervalued in engineering)* | **0.52** | **0.57** | **0.79** | **0.79** |
| Statement 6 *(Diversity is undervalued in engineering)* | **0.52** | 0.38 | **0.78** | **0.77** |

self-efficacy, emotions, and self-advocacy) on a 5-point Likert scale [82]. Cronbach alpha coefficient values of 0.70 or above were considered adequately reliable [83].

### 3.7 Statistical Analysis

For the 153 participants, no missing data on the item sets were found. As such, we conducted the following analysis to assess the instrument. First, a principal component analysis was conducted to explore the number of potential correlated variables in the instrument using a criterion eigenvalue to yield a factored solution. Once the number of factors were determined, a factor loading analysis with varimax rotation was conducted among the relevant factors to measure alignment. Then, Cronbach alpha analysis was conducted to assess the reliability of the instrument as a whole and on each individual scale. Next, Pearson correlation analysis was conducted to explore linear associations between the sub-scale average scores. Finally, variability in sub-scale composite scores and individual questions, by sociodemographic factors, was conducted using analysis of variance (ANOVA).

### 3.8 Human Subjects Research Approval

All procedures described were approved by the Institutional Review Board at the home institution of the first author for the treatment and handling of human subject research data. All participant information was de-identified and aggregated.

## 4. Results

### 4.1 Validity and Reliability Findings

A principal component analysis (PCA) of the 153 participant entries to UPHEME was conducted to explore the number of possible correlated variables in the instrument. The authors identified components using a criterion of eigenvalues exceeding one, which yielded a 6-factor solution, with 4 strong factors and two weak factors based on only one or two items. A second PCA was conducted to hypothesize a four-factor solution, which was then tested (using a criterion of eigenvalues above 2). The latter provided a four-factor model with moderate-to-strong factor loadings [84], which aligned well with the HC awareness, emotions, self-efficacy, and self-advocacy subscales. Results for this analysis are summarized in Table 5.

Next, reliability of the four sub-scales and the accompanying video vignette was analyzed across the 153 participants. Results showed that Cronbach alpha scores for the ranged 0.70 to 0.91 with a full instrument score of 0.74. The summarized findings can be found in Table 6.

### 4.2 Correlation Analysis Findings

To explore the effectiveness of this survey across the sub-scales, a Pearson correlation analysis was conducted on the overall averages of each subscale. From the findings, it appears that self-advocacy and self-efficacy has a significant but moderate negative correlation (Table 7). No other correlation differences were found between the sub-scales.

### 4.3 Analysis of Variance Findings

Sub-scale mean scores were analyzed across the

**Table 6.** Cronbach Alpha Score of the UPHEME instrument items and video; a value of 0.70 or above (bolded in this table) is considered adequately reliable

| Item | Cronbach Alpha |
|---|---|
| HC Awareness | **0.70** |
| Emotions | **0.73** |
| Self-Efficacy | **0.91** |
| Self-Advocacy | **0.91** |
| Full Instrument | **0.74** |

**Table 7.** Pearson correlation for the sub-scale averages between HC awareness (HCA), self-efficacy (SE), emotion (EM) and self-advocacy (SA); * $p < 0.05$

| | HCA | SE | EM | SA |
|---|---|---|---|---|
| HCA | 1 | | | |
| SE | –0.08 | 1 | | |
| EM | 0.448 | 0.02 | 1 | |
| SA | 0.128 | **–0.17*** | 0.11 | 1 |

**Table 8.** Analysis of variance for the sub-scale averages for HC awareness (HCA), self-efficacy (SE), emotion (EM), and self-advocacy (SA) for statements 1 through 6 due to self-reported gender (women and men); * p < 0.05, ** p < 0.01, *** p < 0.001

| | | | Sum of Square | df | Mean Square | F | p-value |
|---|---|---|---|---|---|---|---|
| Statement #1 (access to engineering) | HCA | Between groups | 0.58 | 1 | 0.58 | 0.42 | 0.52 |
| | | Within groups | 210.79 | 150 | 1.41 | | |
| | | Total | 211.37 | 151 | | | |
| | EM | Between groups | 0.26 | 1 | 0.26 | 0.51 | 0.48 |
| | | Within groups | 77.21 | 150 | 0.52 | | |
| | | Total | 77.47 | 151 | | | |
| | SE | Between groups | 0.01 | 1 | 0.01 | 0.01 | 0.93 |
| | | Within groups | 159.46 | 150 | 1.06 | | |
| | | Total | 159.47 | | | | |
| | SA | Between groups | 1.300 | 1 | 1.30 | 1.44 | 0.23 |
| | | Within groups | 135.14 | 150 | | | |
| | | Total | 136.71 | 151 | | | |
| Statement #2 (technical focus of engineering) | HCA | Between groups | 0.402 | 1 | 0.40 | 0.34 | 0.56 |
| | | Within groups | 177.59 | 150 | 1.18 | | |
| | | Total | 177.99 | 151 | | | |
| | EM | Between groups | 1.21 | 1 | 1.21 | 0.01 | 0.92 |
| | | Within groups | 166.99 | 150 | 1.11 | | |
| | | Total | 168.20 | | | | |
| | SE | Between groups | 1.21 | 1 | 1.21 | 1.09 | 0.30 |
| | | Within groups | 166.99 | 150 | 1.11 | | |
| | | Total | 168.20 | 151 | | | |
| | SA | Between groups | 0.84 | 1 | 0.84 | 0.72 | 0.40 |
| | | Within groups | 173.04 | 149 | | | |
| | | Total | 173.88 | 151 | | | |
| Statement #3 (poor performers in engineering) | HCA | Between groups | 0.19 | 1 | 0.19 | 0.16 | 0.69 |
| | | Within groups | 173.19 | 149 | 1.16 | | |
| | | Total | 173.38 | 150 | | | |
| | EM | Between groups | 0.61 | 1 | 0.61 | 1.06 | 0.31 |
| | | Within groups | 86.65 | 150 | 0.58 | | |
| | | Total | 87.26 | 151 | | | |
| | SE | Between groups | 0.13 | 1 | 0.13 | 0.10 | 0.76 |
| | | Within groups | 197.74 | 150 | 1.32 | | |
| | | Total | 197.87 | | | | |
| | SA | Between groups | 1.92 | 1 | 1.92 | 1.47 | 0.23 |
| | | Within groups | 195.84 | 150 | 1.31 | | |
| | | Total | 197.76 | 151 | | | |
| Statement #4 (women in engineering) | HCA | Between groups | 0.31 | 1 | 0.31 | 0.17 | 0.68 |
| | | Within groups | 276.50 | 150 | 1.84 | | |
| | | Total | 276.82 | 151 | | | |
| | EM | Between groups | 0.28 | 1 | 0.28 | 0.56 | 0.45 |
| | | Within groups | 73.19 | 150 | 0.49 | | |
| | | Total | 73.47 | | | | |
| | SE | Between groups | 0.781 | 1 | 0.78 | 0.55 | 0.46 |
| | | Within groups | 211.42 | 150 | 1.41 | | |
| | | Total | 212.20 | 151 | | | |
| | SA | Between groups | 0.24 | 1 | 0.24 | 0.22 | 0.64 |
| | | Within groups | 162.59 | 150 | | | |
| | | Total | 162.84 | 151 | | | |

**Table 8.** (*Continued*)

| | | | Sum of Square | df | Mean Square | F | p-value |
|---|---|---|---|---|---|---|---|
| Statement #5 (soft skills in engineering) | HCA | Between groups | 7.22 | 1 | 7.22 | 3.82 | 0.05 |
| | | Within groups | 283.30 | 150 | 1.89 | | |
| | | Total | 290.52 | | | | |
| | EM | Between groups | 0.00 | 1 | 0.00 | 0.00 | 0.98 |
| | | Within groups | 94.08 | 150 | 0.63 | | |
| | | Total | 94.08 | 1 | | | |
| | SE | Between groups | 0.85 | 1 | 0.85 | 0.61 | 0.44 |
| | | Within groups | 209.12 | 150 | 1.39 | | |
| | | Total | 209.97 | 151 | | | |
| | SA | Between groups | 0.07 | 1 | 0.07 | 0.08 | 0.79 |
| | | Within groups | 149.29 | 150 | 0.99 | | |
| | | Total | 149.37 | 151 | | | |
| Statement #6 (diversity in engineering) | HCA | Between groups | 13.16 | 1 | 13.16 | 7.54 | **0.01**** |
| | | Within groups | 261.78 | 150 | 1.74 | | |
| | | Total | 274.94 | | | | |
| | EM | Between groups | 0.84 | 1 | 0.84 | 1.56 | 0.21 |
| | | Within groups | 80.84 | 150 | 0.54 | | |
| | | Total | 81.68 | 151 | | | |
| | SE | Between groups | 5.32 | 1 | 5.32 | 3.39 | 0.07 |
| | | Within groups | 235.52 | 150 | | | |
| | | Total | 240.84 | 151 | | | |
| | SA | Between groups | 0.00 | 1 | 0.00 | 0.00 | 0.99 |
| | | Within groups | 192.10 | 150 | 1.28 | | |
| | | Total | 192.10 | 151 | | | |
| Overall | HCA | Between groups | 60.67 | 1 | 60.67 | 2.80 | 0.10 |
| | | Within groups | 3247.53 | 150 | 21.65 | | |
| | | Total | 3308.20 | 151 | | | |
| | EM | Between groups | 11.98 | 1 | 11.98 | 0.59 | 0.44 |
| | | Within groups | 3031.07 | 150 | 20.21 | | |
| | | Total | 3043.05 | 151 | | | |
| | SE | Between groups | 30.02 | 1 | 30.20 | 0.92 | 0.34 |
| | | Within groups | 4898.30 | 150 | | | |
| | | Total | 4928.32 | 151 | | | |
| | SA | Between groups | 2.62 | 1 | 2.62 | 0.09 | 0.76 |
| | | Within groups | 4246.58 | 150 | 28.31 | | |
| | | Total | 4249.20 | 151 | | | |

question and by self-identified gender (e.g., women, men), role (e.g., undergraduate student, graduate student, faculty), and institution type (e.g., Hispanic Serving Institution-HSI, Predominantly White Institution-PWI) using ANOVA. The results are summarized in Tables 8, 9, and 10.

For gender, statistical differences were found for HC awareness for statement 6 (diversity is undervalued in engineering; $F_{1,150} = 7.54$; $p = 0.01$; $\eta^2 = 0.05$). For role, statistical differences were found for HC awareness for statement 6 (diversity is undervalued in engineering; $F_{3,149} = 2.82$; $p = 0.04$; $\eta^2 = 0.05$). For institution type, we found statistical differences between HC awareness for statement 1 (not everyone has the same level of access to resources to become an engineer; $F_{2,150} = 4.96$; $p = 0.01$; $\eta^2 = 0.06$). Also, for institution type, we found significant differences among the self-reported positive and negative emotions for statement 2 (prioritization over technical concepts in engineering; $F_{4,148} = 6.62$; $p = 0.00$; $\eta^2 = 0.08$) where HSI participants expressed very negative emotions towards the assumption that technical aspects of engineering are prioritized in its education ($M = 1.74$, SD = 0.72) whereas PWI participants were less negative about this assumption ($M = 2.20$, SD =

**Table 9.** Analysis of variance for the sub-scale averages for HC awareness (HCA), self-efficacy (SE), emotion (EM), and self-advocacy (SA) for statements 1 through 6 due to self-reported role (faculty, graduate students, undergraduate students); * p < 0.05, ** p < 0.01, *** p < 0.001

| | | | Sum of Square | df | Mean Square | F | p-value |
|---|---|---|---|---|---|---|---|
| Statement #1 (access to engineering) | HCA | Between groups | 8.89 | 3 | 2.96 | 2.17 | 0.09 |
| | | Within groups | 202.64 | 149 | 1.36 | | |
| | | Total | 211.50 | 152 | | | |
| | EM | Between groups | 0.25 | 3 | 0.08 | 0.16 | 0.92 |
| | | Within groups | 77.41 | 149 | 0.52 | | |
| | | Total | 77.66 | 152 | | | |
| | SE | Between groups | 1.44 | 3 | 0.48 | 0.45 | 0.72 |
| | | Within groups | 158.86 | 149 | 1.07 | | |
| | | Total | 160.12 | 152 | | | |
| | SA | Between groups | 2.34 | 3 | 0.78 | 0.86 | 0.46 |
| | | Within groups | 135.19 | 149 | 0.91 | | |
| | | Total | 137.53 | 152 | | | |
| Statement #2 (technical focus of engineering) | HCA | Between groups | 1.34 | 3 | 0.45 | 0.38 | 0.77 |
| | | Within groups | 176.89 | 149 | 1.19 | | |
| | | Total | 178.24 | 152 | | | |
| | EM | Between groups | 0.36 | 3 | 0.12 | 0.22 | 0.89 |
| | | Within groups | 83.87 | 149 | 0.56 | | |
| | | Total | 84.24 | 152 | | | |
| | SE | Between groups | 2.72 | 3 | 0.91 | 0.81 | 0.49 |
| | | Within groups | 166.34 | 149 | 1.12 | | |
| | | Total | 169.06 | 152 | | | |
| | SA | Between groups | 6.05 | 3 | 2.02 | 1.77 | 0.16 |
| | | Within groups | 169.00 | 148 | 1.14 | | |
| | | Total | 175.05 | 151 | | | |
| Statement #3 (poor performers in engineering) | HCA | Between groups | 1.42 | 3 | 0.47 | 0.41 | 0.75 |
| | | Within groups | 172.16 | 148 | 1.16 | | |
| | | Total | 173.58 | 151 | | | |
| | EM | Between groups | 1.50 | 3 | 0.50 | 0.86 | 0.46 |
| | | Within groups | 86.27 | 149 | 0.58 | | |
| | | Total | 87.77 | 152 | | | |
| | SE | Between groups | 0.47 | 3 | 0.16 | 0.12 | 0.95 |
| | | Within groups | 198.17 | 149 | 1.33 | | |
| | | Total | 198.64 | 152 | | | |
| | SA | Between groups | 6.65 | 3 | 2.22 | 1.72 | 0.17 |
| | | Within groups | 192.03 | 149 | 1.29 | | |
| | | Total | 198.68 | 152 | | | |
| Statement #4 (women in engineering) | HCA | Between groups | 4.78 | 3 | 1.59 | 0.86 | 0.46 |
| | | Within groups | 275.46 | 149 | 1.85 | | |
| | | Total | 280.24 | 152 | | | |
| | EM | Between groups | 0.62 | 3 | 0.21 | 0.42 | 0.74 |
| | | Within groups | 73.04 | 149 | 0.49 | | |
| | | Total | 73.66 | 152 | | | |
| | SE | Between groups | 2.99 | 3 | 0.99 | 0.71 | 0.55 |
| | | Within groups | 209.89 | 149 | 1.41 | | |
| | | Total | 212.88 | 152 | | | |
| | SA | Between groups | 7.65 | 3 | 2.55 | 2.44 | 0.07 |
| | | Within groups | 155.70 | 149 | 1.04 | | |
| | | Total | 163.35 | 152 | | | |

**Table 9.** (*Continued*)

| | | | Sum of Square | df | Mean Square | F | p-value |
|---|---|---|---|---|---|---|---|
| Statement #5 (soft skills in engineering) | HCA | Between groups | 1.15 | 3 | 0.38 | 0.20 | 0.90 |
| | | Within groups | 292.08 | 149 | 1.96 | | |
| | | Total | 293.23 | 152 | | | |
| | EM | Between groups | 0.64 | 3 | 0.21 | 0.34 | 0.80 |
| | | Within groups | 93.53 | 149 | 0.63 | | |
| | | Total | 94.17 | 152 | | | |
| | SE | Between groups | 0.15 | 3 | 0.05 | 0.03 | 0.99 |
| | | Within groups | 210.80 | 149 | | | |
| | | Total | 210.94 | 152 | | | |
| | SA | Between groups | 1.97 | 3 | 0.66 | 0.66 | 0.58 |
| | | Within groups | 148.14 | 149 | 0.99 | | |
| | | Total | 150.12 | 152 | | | |
| Statement #6 (diversity in engineering) | HCA | Between groups | 14.96 | 3 | 4.99 | 2.82 | **0.04*** |
| | | Within groups | 263.88 | 149 | 1.77 | | |
| | | Total | 278.84 | 152 | | | |
| | EM | Between groups | 1.09 | 3 | 0.36 | 0.67 | 0.57 |
| | | Within groups | 80.88 | 149 | 0.54 | | |
| | | Total | 81.97 | 152 | | | |
| | SE | Between groups | 1.01 | 3 | 0.34 | 0.21 | 0.89 |
| | | Within groups | 240.76 | 149 | 1.62 | | |
| | | Total | 241.77 | 152 | | | |
| | SA | Between groups | 6.34 | 3 | 2.11 | 1.69 | 0.17 |
| | | Within groups | 186.50 | 149 | 0.99 | | |
| | | Total | 192.84 | 152 | | | |
| Overall | HCA | Between groups | 46.10 | 3 | 15.37 | 0.69 | 0.56 |
| | | Within groups | 3308.34 | 149 | 22.20 | | |
| | | Total | 3354.44 | 152 | | | |
| | EM | Between groups | 6.64 | 3 | 2.21 | 0.11 | 0.96 |
| | | Within groups | 3077.38 | 149 | 20.65 | | |
| | | Total | 3084.01 | 152 | | | |
| | SE | Between groups | 20.64 | 3 | 6.88 | 0.21 | 0.89 |
| | | Within groups | 4936.59 | 149 | 33.13 | | |
| | | Total | 4957.23 | 152 | | | |
| | SA | Between groups | 153.77 | 3 | 51.26 | 1.85 | 0.14 |
| | | Within groups | 4124.70 | 149 | 27.68 | | |
| | | Total | 4278.47 | 152 | | | |

0.70). Institution type also demonstrated a statistically significant response for statement 3 (poor performers in engineering; $F_{4,148}$ = 5.27; p = 0.01; $\eta^2$ = 0.07) whereas HSI participants expressed very negative emotions about the assumptions of poor performers in engineering (*M* = 1.60, SD = 0.70) while PWI participants were less negative about this assumption (*M* = 2.10, SD = 0.85).

## 5. Discussion

The aim for this study was to develop and assess a mixed-methods vignette survey instrument to explore HC and its related constructs. For UPHEME, we found reliability scores at or exceeding 0.70 suggesting an adequately reliable scale for our intended engineering population. From the PCA analysis, we identified a four-factor model (HC awareness, emotions, self-efficacy, and self-advocacy) with factor loading values that are indicative of moderate-to-strong loading across the six statements, with the exception of the diversity statement (#6) for emotions. It is possible that there are varied interpretations of diversity that are guided by different interpretations of emotions around these topics or that additional participants

**Table 10.** Analysis of variance for the sub-scale averages for HC awareness (HCA), self-efficacy (SE), emotion (EM), and self-advocacy (SA) for statements 1 through 6 (subscript added to each sub-scale) due to institution type (Hispanic Serving Institution, Predominantly White Institution); * p < 0.05, ** p < 0.01, *** p < 0.001

| | | | **Sum of Square** | **df** | **Mean Square** | **F** | **p-value** |
|---|---|---|---|---|---|---|---|
| Statement #1 (access to engineering) | HCA | Between groups | 13.11 | 2 | 6.56 | 4.96 | **0.01**** |
| | | Within groups | 198.39 | 150 | 1.32 | | |
| | | Total | 211.50 | 152 | | | |
| | EM | Between groups | 0.97 | 2 | 0.49 | 0.95 | 0.39 |
| | | Within groups | 76.69 | 150 | 0.51 | | |
| | | Total | 77.66 | 152 | | | |
| | SE | Between groups | 0.64 | 2 | 0.32 | 0.30 | 0.74 |
| | | Within groups | 159.47 | 150 | 1.06 | | |
| | | Total | 160.12 | 152 | | | |
| | SA | Between groups | 0.98 | 2 | 0.49 | 0.54 | 0.58 |
| | | Within groups | 136.55 | 150 | 0.91 | | |
| | | Total | 137.53 | 152 | | | |
| Statement #2 (technical focus of engineering) | HCA | Between groups | 2.36 | 2 | 1.18 | 1.00 | 0.37 |
| | | Within groups | 175.88 | 150 | 1.17 | | |
| | | Total | 178.24 | 152 | | | |
| | EM | Between groups | 6.83 | 2 | 3.42 | 6.62 | **0.00***** |
| | | Within groups | 77.40 | 150 | 0.52 | | |
| | | Total | 84.24 | 152 | | | |
| | SE | Between groups | 1.98 | 2 | 0.99 | 0.89 | 0.41 |
| | | Within groups | 167.80 | 150 | 1.11 | | |
| | | Total | 169.06 | 152 | | | |
| | SA | Between groups | 5.33 | 2 | 2.66 | 2.34 | 0.10 |
| | | Within groups | 169.73 | 149 | 1.14 | | |
| | | Total | 175.05 | 151 | | | |
| Statement #3 (poor performers in engineering) | HCA | Between groups | 0.03 | 2 | 0.02 | 0.01 | 0.99 |
| | | Within groups | 173.55 | 149 | 1.17 | | |
| | | Total | 178.24 | 152 | | | |
| | EM | Between groups | 5.76 | 2 | 2.88 | 5.27 | **0.01**** |
| | | Within groups | 82.00 | 150 | 0.55 | | |
| | | Total | 87.77 | 152 | | | |
| | SE | Between groups | 0.88 | 2 | 0.44 | 0.33 | 0.72 |
| | | Within groups | 197.76 | 150 | 1.32 | | |
| | | Total | 198.64 | 152 | | | |
| | SA | Between groups | 2.47 | 2 | 1.24 | 0.94 | 0.39 |
| | | Within groups | 196.21 | 150 | 1.31 | | |
| | | Total | 198.86 | 152 | | | |
| Statement #4 (women in engineering) | HCA | Between groups | 3.66 | 2 | 1.83 | 0.99 | 0.37 |
| | | Within groups | 276.58 | 150 | 1.84 | | |
| | | Total | 280.24 | 152 | | | |
| | EM | Between groups | 1.73 | 2 | 0.87 | 1.81 | 0.17 |
| | | Within groups | 71.93 | 150 | 0.48 | | |
| | | Total | 73.66 | 152 | | | |
| | SE | Between groups | 6.07 | 2 | 3.03 | 2.20 | 0.11 |
| | | Within groups | 206.81 | 150 | 1.38 | | |
| | | Total | 212.88 | 152 | | | |
| | SA | Between groups | 3.65 | 2 | 1.83 | 1.71 | 0.18 |
| | | Within groups | 159.97 | 150 | 1.07 | | |
| | | Total | 163.35 | 152 | | | |

**Table 10.** (*Continued*)

| | | | Sum of Square | df | Mean Square | F | p-value |
|---|---|---|---|---|---|---|---|
| Statement #5 (soft skills in engineering) | HCA | Between groups | 8.87 | 2 | 4.43 | 2.34 | 0.10 |
| | | Within groups | 284.36 | 150 | 1.84 | | |
| | | Total | 280.24 | 152 | | | |
| | EM | Between groups | 1.79 | 2 | 0.89 | 1.45 | 0.24 |
| | | Within groups | 92.38 | 150 | 0.62 | | |
| | | Total | 94.17 | 152 | | | |
| | SE | Between groups | 1.25 | 2 | 0.63 | 0.45 | 0.64 |
| | | Within groups | 209.69 | 150 | 1.40 | | |
| | | Total | 210.94 | 152 | | | |
| | SA | Between groups | 1.04 | 2 | 0.52 | 0.52 | 0.60 |
| | | Within groups | 149.08 | 150 | 0.99 | | |
| | | Total | 150.12 | 152 | | | |
| Statement #6 (diversity in engineering) | HCA | Between groups | 9.34 | 2 | 4.67 | 2.60 | 0.08 |
| | | Within groups | 269.50 | 150 | 1.80 | | |
| | | Total | 278.84 | 152 | | | |
| | EM | Between groups | 0.96 | 2 | 0.48 | 0.89 | 0.41 |
| | | Within groups | 81.01 | 150 | 0.54 | | |
| | | Total | 81.97 | | | | |
| | SE | Between groups | 3.42 | 2 | 1.71 | 1.08 | 0.34 |
| | | Within groups | 238.35 | 150 | 1.59 | | |
| | | Total | 241.77 | 152 | | | |
| | SA | Between groups | 7.41 | 2 | 3.71 | 3.00 | 0.05 |
| | | Within groups | 185.43 | 150 | 1.24 | | |
| | | Total | 192.84 | 152 | | | |
| Overall | HCA | Between groups | 116.72 | 2 | 58.36 | 2.70 | 0.70 |
| | | Within groups | 3237.73 | 150 | | | |
| | | Total | 3354.44 | 152 | | | |
| | EM | Between groups | 188.86 | 2 | 94.43 | 4.89 | **0.01**** |
| | | Within groups | 2895.15 | 150 | 19.30 | | |
| | | Total | 3084.01 | 152 | | | |
| | SE | Between groups | 72.86 | 2 | 36.43 | 1.12 | 0.33 |
| | | Within groups | 4484.37 | 150 | 32.56 | | |
| | | Total | 4957.23 | 152 | | | |
| | SA | Between groups | 104.94 | 2 | 52.47 | 1.89 | 0.16 |
| | | Within groups | 4173.53 | 150 | 27.82 | | |
| | | Total | 4278.47 | 152 | | | |

are needed for analysis. Studies have suggested that framing to emotional topics may subliminally result in different responses that may vary by culture [84]. However, it is possible that in particular, topics of diversity may have led to discrepant implicit or explicit biases from the participants [85] as they responded to this question. Additional work is needed to differentiate between these or other possibilities.

It was interesting that even with the framing of the survey, differential responses were found among participants for the four sub-scales. For HCA, we found differences due to institutional type, role and gender particularly around issues of diversity and access of resources in engineering. Regarding issues of diversity in engineering, we found an overall increase in recognition of this statement among faculty and women. This finding mirrors earlier work from our group [5] suggesting the role that professionalization and gendered (or minoritized) experiences in engineering may have in heightening participants' awareness to diversity issues. It is interesting also, that HSI participants had a higher recognition that not everyone has access to resources in engineering compared to PWI participants. This suggests variation in organizational characteristics, regional, and contextual differences among these institutions [86–88].

For emotions, it was interesting to note institution-specific differences where higher incidences of negative emotions were reported among HSI participants compared to PWI participants around issues of limited socio-cultural exposure in engineering education. This may point to differences in institutional values and cultures based on student and faculty make-up. Also, this finding further supports the need to contextualize findings to community, cultural, systemic, and other historical realities [35, 38, 39, 40, 87–90] of diverse engineering groups.

For self-efficacy, marginal statistical differences were found due to gender around issues of diversity in engineering where women had a higher perceived self-efficacy ($M$ = 4.30, SD = 0.95) about their ability to succeed in engineering despite the notion that diversity in engineering is undervalued compared to men ($M$ = 3.90, SD = 1.38). This is an encouraging finding and is indicative of a potential cultural shift and attitude among underrepresented women in engineering, despite the notion of a man-dominated environment in engineering [35, 87–90].

For self-advocacy, marginal differences due to role were found on issues of the underrepresentation of women in engineering where faculty expressed a higher willingness ($M$ = 5.00, SD = 0.00) to advocate for this issue over graduate students ($M$ = 3.89, SD = 1.25) and undergraduate students ($M$ = 3.99, SD = 1.18). This finding may speak to either a potential lack understanding or power that students may perceive they have when understanding what is needed to advocate for these issues within the systemic structures of academia. Furthermore, marginal differences were found between institution types around limited socio-cultural exposures in engineering education where HSI participants had a higher willingness to advocate for this issue ($M$ = 4.01, SD = 1.02) compared to PWI participants ($M$ = 3.59, SD = 1.23). Furthermore, around issues of diversity in engineering, HSI participants also expressed a higher willingness to advocate ($M$ = 4.26, SD = 1.05) compared to PWI participants ($M$ = 3.74, SD = 1.31). While the differences around these issues were marginal, this presents an interesting and concerning picture. First, both HSI and PWI participants recognize the invisible barriers that may deter success in engineering [89, 90]. It was concerning, however, that PWI participants did not express a higher willingness to advocate for diversity compared to HSI participants. This speaks to either a lack of awareness of the problems underrepresented groups face in engineering or that there is a lack of understanding of how to go about advocating for such issues at their institutions. Early literature in hidden curriculum has suggested that "if our concern is not simply to discover hidden curricula but to do something about them, we must find out which elements or aspects of a given setting help bring about which components of that setting's hidden curriculum. For if we do not know the sources . . . to a hidden curriculum, we must either let that hidden curriculum be or do away with the whole setting." [91, p.141]. In other words, we must be intentional in understanding and reflecting upon the reasons and underpinning factors that contribute to the existence of a particular hidden curriculum at a given site or context. To add to this point, we must not only reflect on the roots of hidden curriculum, but we must look forward to creating meaningful advocacy actions that will minimize any inadvertent, new, or exacerbated negative outcomes for other individuals.

Collectively, the data points to the contextual and situational differences in engineering experiences across the participants in varying institutions, and potentially intersectional [88] elements behind HC awareness and action. This work also demonstrates the impact that a mixed-method instrument exploring HC pathways has in identifying both the elements behind HC as well as the potential responses and consequences of recognizing these assumptions in engineering education.

## 6. Limitations

This paper presents the quantitative findings from 153 participants for the purpose of developing and assessing a novel survey instrument on the topic of hidden curriculum in engineering. One limitation of the study is that we did not include the qualitative responses from these participants in this study, which would have allowed us to further contextualize the findings from this work. However, the inclusion of the four proposed HC response pathways and statistical findings presents a unique picture of the differential responses from participants in varying contexts.

Another limitation to this study is that while we did disaggregate our findings by self-identified gender, institutional type, and role, we did not further contextualize it based on elements of intersectionality [88–90]. This is a next step in our research. After this manuscript, the authors recruited additional participants with this version of the instrument. With a greater number of participants, it is the authors' expectations that more nuanced responses may be found.

Furthermore, due to the exploratory nature of this research, there were no statistical corrections made for multiple comparisons between the sub-scales and the demographic subgroups. Additional confirmatory analysis should adjust for multiplicity and account for Type I errors.

Finally, although our instrument may be reliable and valid, it does not mean that it will work across all populations and for all purposes. We caution researchers to keep the utility and purpose of this instrument in mind for future studies.

## 7. Implications

The findings from this work is beginning to point to the need for contextual and situational interventions aimed at debunking or supporting participants' divergent experiences about engineering education. The topic of hidden curriculum in engineering is still very new and developing an instrument of this design can better position educators, administrators, and researchers to understand not just the primary challenges in engineering education but shed light on new interventions in the process. The findings from the 153 participants in this initial study suggests that institutions should conduct studies of this nature at their sites to uncover potential issues that they may not be aware of in their colleges of engineering and departments. Findings from this work will help create greater consciousness of the impact that hidden curriculum can have in the formation of values, beliefs, and attitudes in engineering.

Furthermore, with the introduction of the UPHEME instrument, the originality in its design, and the uniqueness of its organization, may help better understand of the considerations and pathways that may be involved when responding to HC in engineering. Among these considerations, positionalities based on an individual's belief, emotions, self-efficacy stances, and willingness for advocacy can now be considered holistically in engineering. As Fink and Stoll posit, "Change strategies that ignore the meanings, emotions, and cultures of schools, we would submit, are doomed for failure." [92, p. 37].

## 8. Conclusion

In our research, we developed the first mixed-method vignette survey instrument around the topic of hidden curriculum in engineering. In its design, we considered hidden curriculum to not be an isolated phenomenon but intertwined with potential constructs (e.g., self-efficacy) that can influence an individual's responses and inclinations to pursue change in their engineering education. In this study, we found that HC awareness, emotions, self-efficacy, and self-advocacy and their pertinent responses on the topics presented can help uncover unique and differential views, beliefs, values, and attitudes among participants. Primarily, we found that HC awareness is central to helping us understand participants' responses to these engineering norms. Alongside HC awareness, we found that among different axes of inequity, gender, role, and institution type result in varying responses that may help scholars understand the unique landscape these populations face in their engineering education. Our findings confirm that topics around socio-cultural education and diversity initiatives in engineering education are currently underdeveloped. Also, one unique finding in our study was the role that HC awareness has among different populations, which may warrant additional contextual and intersectional considerations in the future.

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