ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #36562

Engineering Students Conceptions of The Hidden Curriculum in Hispanic-Serving Institutions: Learning to Inform Practice

Idalis Villanueva (Associate Professor)

For the past 10 years, Dr. Idalis Villanueva has worked on several engineering education projects where she derives from her experiences in engineering to improve outcomes for minoritized groups in engineering using mixed-and multi-modal methods approaches. She currently is an Associate Professor in the Engineering Education Department at the University of Florida. In 2019, she received the Presidential Early Career Award for Scientists and Engineers (PECASE) award for her NSF CAREER project on hidden curriculum in engineering. Dr. Idalis Villanueva has a B.S. degree is in Chemical Engineering from the University of Puerto Rico at Mayagüez and a M.S. and Ph.D. degree in Chemical and Biological Engineering from the University of Colorado-Boulder. Soon after, she completed her postdoctoral fellowship from the National Institutes of Health in Analytical Cell Biology in Bethesda, Maryland and worked as a lecturer for 2 years before transitioning to a tenure-track in engineering education. Her experiences as a first-generation engineer, Latinx, woman of color, introvert, and mother has shaped the lens and research-informed practical approaches that she uses in her research.

Cijy Elizabeth Sunny (Dr) (Baylor University)

Cijy Elizabeth Sunny, Ph.D. is an educator, research methodologist, and psychometrician who has applied her skills in quantitative, mixed methods, qualitative research, and psychometrics in the substantive areas of STEMM education research, medical education, engineering education, and more recently human trafficking, online abuse/support, and its impact on IT identity. She continues to invest her skills in discipline-specific STEMM education research and teaching.

Engineering Students Conceptions of The Hidden Curriculum in Different Institution Types: A Comparative Study

Abstract

Hidden Curriculum (HC) consists of the unacknowledged and often, unintentional exclusionary systemic messages that are structurally supported and sustained [1]. Due to the persistent influence of HC in helping establish the norm in educational and working environments, research in this topic is gaining prominence in fields like engineering. This paper contributes to the knowledge base by exploring the level of HC awareness (HCA) and the definitions that over 600 undergraduate engineering students across Hispanic-Serving and non-Hispanic Serving Institutions ascribed to when defining HC. Using mixed-methods analysis, two-factor ANOVA was conducted on the quantitative items of HCA, at the intersection of self-identified gender and institutional type. The first round of coding was followed by open and axial coding of the written definitions provided by the participants. Results suggest there were significant differences in levels of HCA between HSIs and non-HSIs with other institutions (e.g, HEIs) having the highest levels of HCA. The responses to the open-ended question yielded four specific themes: (a) Confirmation of Existence of HC; (b) Attribution of HC to Cognitive Elements; (c) Attribution of HC to Socio-Humanistic Elements; and (d) Refusal of Existence of HC. A discussion of its implications was included in this paper.

Introduction

The motivation for this study was to explore, in more detail, the role that HCA may have on individuals' response to, and/or their recognition of, the HC. Individuals' responses and/or recognitions in their definitions of the HC may have as a function of self-identified gender and institution type. HC is composed of hidden systematically transmitted rules, assumptions, values, and beliefs, to name a few, that are not openly acknowledged in each environment [1]-[11]. This work builds upon previous work that quantified the levels of HCA amongst 224 undergraduate students, graduate students, and engineering faculty in engineering [1].

Background

In that early study, Villanueva et al. [1] found that undergraduate students in engineering had the most difficulty in recognizing the HC surrounding their education compared to graduate students and faculty. However, for those undergraduate students that did recognize the HC, there was an acknowledgement of the role that educational systems played in cuing individuals' sense of belonging [1]. In a separate study, the authors explored how HCA varied by institutional type and found differences between Hispanic Serving Institutions (HSI) and Predominantly White Institutions (PWI) on issues of diversity and access of resources in engineering [12]. What was unclear from these two studies was how the context of the educational system (i.e., institutional type) differently influenced the way individuals of different identities (e.g., self-identified gender) responded to or recognized the HC. This study serves as an early exploration into this unknown.

Hidden Curriculum in Engineering:

While still in its infancy, studying the HC in engineering is gaining momentum across national and international circles [2]-[16]. Traditionally viewed as implicit messaging for women in engineering learning and research environments [2], [3], Villanueva [4] (re)introduced the HC as a structural framework that contains several interconnected pathways (awareness, emotions, self-efficacy, and self-advocacy; each are described in the paragraph below). According to sociology scholars [17]-[19], structural frameworks consider how moving parts of a system (e.g., common norms, customs, traditions, and cultures) are structurally supported and sustained to promote stability and solidarity amongst its actors (individuals or groups).

In HC, the interconnected pathways described by Villanueva et al., [12] consist of four factors: hidden curriculum awareness (HCA; Factor 1), emotions (EM; Factor 2), self-efficacy (SE; Factor 3), and self-advocacy (SA; Factor 4). HCA helps individuals sub-consciously recognize and discern how and what information is communicated to them via structures and/or systems. HCA requires that a person recognizes the HC first, either on their own [12] or through assistance [8] and is considered an independent factor according to ongoing latent variable analysis in our research [20]. Emotions assist individuals in differentiating the HC messages, cues, and factors that lead to decision-making and their subsequent actions [13]. EM is a mediating factor [21]. Higher SE motivates individuals to take actions, like changing their environment, whereas lower SE leads to higher avoidant strategies [14]. SE is also a mediating factor [20]. Based on a person's level of SE, an individual will opt to develop strategies to cope with the HC around them, in the form of SA [14], which is an outcome [20].

The focus of this paper is to explore HCA among undergraduate students in engineering as early work suggested that students at this stage in their education are receiving the most formalized form of curriculum and hardly recognize HC [1].

Hidden Curriculum Awareness (HCA) in engineering:

While it is important to reveal any potential social, political, or educational interferences that the HC may uncover, the "task of enabling people to understand what motivates such interference is perhaps even more important" [22, p. 177]. As such, HCA, which is considered a recognition pathway found in a person's consciousness [12], cannot be disconnected from the contextual realities that normative environments carry to promote stability and solidarity amongst its actors (individuals or groups) [17]-[19]. Depending on the level of normativity present in any given environment, system, or structure, an individual can unconsciously or meta-consciously (mis)represent the cues they acquire [12], [14]. Thus, HCA is contextual and situational [12], [14] and can lead to differential outcomes such as persistence and belonging [1].

Thus far, HCA in engineering has only been explored by early work conducted by Villanueva et al. [1], [12]. HCA was first explored in a subset of 224 participants (undergraduate students, graduate students, and faculty) in early iterations of an instrument [1] that was later tested for reliability, validated, and named UPHEME, an old English term signifying to overturn or upend [12]. For the former study, Villanueva et al., found that undergraduate students in engineering received a more formal curriculum (~60%) and had less HC awareness (~28%) compared to graduate students and faculty [1].

In a follow-up study using UPHEME, a sub-analysis of 153 participants was done to validate and test the reliability of the instrument. As part of that study, an ANOVA sub-analysis was conducted to explore how HCA varied by institutional type [12]. In that study, Villanueva et al., [12] found statistically significant differences between Hispanic Serving Institutions (HSI) and Predominantly White Institutions (PWI) on issues of diversity and access of resources in engineering [12]. Also, HCA differences were found due to institutional type, role, and gender, particularly around issues of diversity and access of resources in engineering [12]. What was unclear from that study was how the context of the educational system (i.e., institutional type) differentially influenced individuals of varying identities (gender, race, etcetera) and how these institutional contexts may have influenced their HCA. Villanueva et al., [12] also acknowledged that at the time of these early studies [1], [12], data collection was not completed, and that future work would be needed to present a more comprehensive set of findings from the UPHEME instrument.

The following study serves as an expansion of the original explorations [1], [12]. More specifically, this study explores the intersection of institutional type (HSI and non-HSI) and self-identified gender, and how these may have influenced HCA and their subsequent interpretation of what HC is in engineering. Additionally, we focused on a more complete set of undergraduate engineering students from the UPHEME instrument although future work will include engineering graduate students and faculty.

Research Questions

The purpose of this study was to explore and understand how undergraduate engineering students at HSIs and non-HSIs differed in their HCA and what interpretations of what HC is in engineering entail. The research questions (RQs) are:

RQ1. How do undergraduate engineering students at HSIs differ in their HCA compared to non-HSIs?

- Sub-RQ1. How did their HCA differ by institutional type and self-identified gender?

RQ2. Which HC assumptions, if any, did the students ascribe (respond or recognize) to the most based on how they defined HC?

- Sub-RQ2. How do these differ by institutional type and self-identified gender?

Research Design

The research presented here is a subset of a major National Science Foundation (NSF) funded study (EEC-1653140 & 2123016). The major research study is centered around a complex, mixed-method experimental intervention design, where qualitative and quantitative data collection and analysis was merged in a convergent form [12]. For this exploration, a secondary data analysis was performed on a subset of the data collected from UPHEME. As such, our analysis includes the results of the quantitative and qualitative components of the HCA factor of the UPHEME instrument and will draw inferences that integrate the results [23].

Methods

Hidden Curriculum Awareness (UPHEME, Factor 1):

As shown in Table 1 and as discussed in an earlier study [12], due to the complex and potentially fragile nature of this topic, a vignette approach was used in the design, testing, and validation of the UPHEME instrument. In brief, since earlier work from this research team [4], [7]-[14] found that engineering students and faculty do not easily recognize the HC due to the hyper-rational culture of engineering [24], [25], a vignette survey was developed to help participants respond to a familiar contextual situation. In the process, framing can assist participants to see and feel the HC that wasn't identified before [7] rather than expecting participants to infer on its meaning. The placement of the items of the survey and per factor described in [12], were included intentionally to "allow the video vignette to serve as a point of recognition and reflection between the HC statements" [12, p. 1555] and to "minimize any potential 'mental shortcuts' that participants could use to make sense of a new concept or phenomenon" [12, p. 1555]. Since framing has an influence over interpretation of meanings, the research team wanted to make sure its placement would minimize potential variations in participants' understanding of HC [12]. The inclusion of the follow-up qualitative question per factor served to confirm or disprove which of the six assumption statements (Table 1) participants attribute most in their definition, if any. The follow-up question also allowed the researchers to identify potential deviations from the originally provided definition of the term. Collectively, the quantitative item served to answer RQ1 and its connected sub-question while the qualitative item (open-ended question) served to answer RQ2 and its connected sub-question.

Data Collection:

As described in [12] and [14], a two-stage data collection for UPHEME was conducted during 2018-2019. The first stage included a purposeful sampling strategy [27] conducted with the original five institutions affiliated with the grant (see Acknowledgement section) under the following inclusion criteria: (1) an ABET-accredited college of engineering in the United States and Puerto Rico, (2) students or faculty who are currently enrolled or employed in that college of engineering, (3) over the age of 18, and (4) a U.S. citizen or permanent resident. This recruitment was purposeful in order to oversample populations that are traditionally underrepresented in engineering (e.g., Latinx, Black). From this effort, 564 responses were collected. The second stage of recruitment involved probabilistic sampling [27] to capture other regions of the U.S. and Puerto Rico across multiple colleges of engineering and institution types. From this stage, an additional 420 responses were collected. The total number of participants were 984. All participants were paid an Amazon gift card ($25) for their entries to the UPHEME instrument, which took approximately 20 minutes to complete. All procedures followed Institutional Review Board approved protocols.

Table 1. Sequencing of the HCA factor in the UPHEME instrument [12] used for the study

Sequence	Description	HC Items/Assumptions
HCA (Quan)	*Hidden curriculum 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? Likert Scale: 1-*Definitely Not* 2-*Probably Not* 3- *Possibly* 4-*Very Probably* 5- *Definitely Yes*	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.
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.	N/A
HCA (Qual)	In your own words, define *hidden curriculum*.	N/A

Data Cleaning and Missing Data Analysis:

Prior to analyzing the data collected from the UPHEME instrument, the research team cleaned the data based on the following criteria: (1) number of repeat response IDs; (2) questionable entries (e.g., trolling answers); and (3) no responses to any of the survey questions. After these were deleted, we had a sample of 961 responses. More than 3% of data had missing values with no specific pattern of missingness [26]. What this pattern of missingness signifies is that there were individuals who did not respond to some questions of the survey and/or some demographic questions, which were vital to this research. For these respondents, the research team abided by missing data standards [26] and applied multiple imputation (MI) after verifying that missing data occurred at random [26]. For MI, missing values were predicted using the observed data and their associations creating multiple imputed datasets [28],[29]. After this cleaning and imputation process, 961 responses were considered ‘complete’. For the present study, we focused only on

the undergraduate student responses, which constitutes ~70% of responses (*n*=671). A demographic breakdown of the participants for this study is presented in Table 2.

Table 2. Select Demographic Breakdown of Undergraduate Participants

Demographic	**Sample Size (%)**
Self-identified Gender	
Female	247 (37)
Male	422 (63)
Other	2 (0.3)
Institutional Type	
HSI (public + private)	175 (26)
HSI (public)	56 (8)
HSI (private)	119 (18)
PWI	269 (40)
Other (e.g., community college, HBCU, HEI, etc.)	224 (33)
Race and/or Ethnicity	
Hispanic, Latina/o, Chicana/o (e.g., Mexican, Puerto Rican, etc.) +	179 (27)
White (e.g., German, Irish, Lebanese, etc.)	338 (50)
Other	153 (23)
First-generation (i.e., first one attending college from their immediate family) *	
Yes	260 (39)
No	400 (59)
Non-traditional undergraduate student (i.e., a student who is at least 25 years of age or older and/or has a spouse, committed partner, or dependents) *	
Yes	233 (35)
No	417 (62)

Note. *The table does not include *not sure* responses. Also, the researchers recognize the use of the term 'post-traditional' as a more representative term compared to 'non-traditional' to describe the working and care-taking responsibilities of individuals. However, to keep consistent with the original design of the UPHEME instrument, the original term was maintained.

+ The table describes Hispanic as an ethnic identity to encompass evolving terminologies at the time of the study although we acknowledge the more inclusive terms of Latinx/a/o/é.

Analysis:

As the focus of this study was to look at group mean differences based on the type of institution, self-identified gender, and the intersection of the grouping variables for HCA, a two-factorial ANOVA was used to analyze the quantitative data. This analysis was performed in SPSS 28 [30]. There were four different groupings of institutions, namely, public HSIs, private HSIs, PWIs, and Others. The Others grouping consisted of predominantly Hispanic Enrolling Institutions (HEI) where a high percentage of Latinx/Hispanicx enroll in an institution of higher education but does not reach 25%, which is typically required to achieve a HSI classification. We deemed it important to consider HSIs as a whole in the analysis but also split out the HSIs into private and public since their funding structures are and their institutional contexts are different.

For self-identified gender, the terms female, male, and other (that included non-binary, prefer to self-describe, or prefer to not say) were retained from the original instrument. For statistical analysis, the authors removed the 'other' category in self-identified gender due to the small sample size (n=2). However, the 'other' category is better represented amongst graduate students and faculty; this data is being analyzed qualitatively in a separate study.

A constant comparative approach was used in where the quantitative data was compared against the qualitatively coded responses. This approach allowed the researchers to better understand how students' definition reflected one or more of the six assumptions statements (see Table 1). The qualitative item was coded using a combination of open and axial coding leading to four themes [31].

For integration of the qualitative and quantitative data to meet mixed-methods research criteria [12], [27], the authors first recognized that HCA was a unidimensional measure as established through the validation process [12], [21]. Thus, a composite score for HCA was calculated. A composite score could either be an average or a sum score and this is an acceptable way to analyze Likert scale data. The composite scores were then considered on an interval scale [32]. The quantitative survey data was analyzed by calculating the average for each participant for the latent construct namely HC awareness. These averages helped the researchers to better interpret the context of how students endorsed a specified HCA rating scale. When compared alongside the open-ended question, the research team could have a better sense of which HC assumption statement resonated most with the participants.

Results and Discussion

Quantitative Findings - Hidden Curriculum Awareness:

As summarized in Table 3, it appears that undergraduate students who self-identified as female, had higher HCA ratings (*very probably* to *definitely yes*) across institution types except for HSI public in where male and female participants reported mid-levels of HCA. To test if there were significant differences in their means, a two-factor ANOVA was performed.

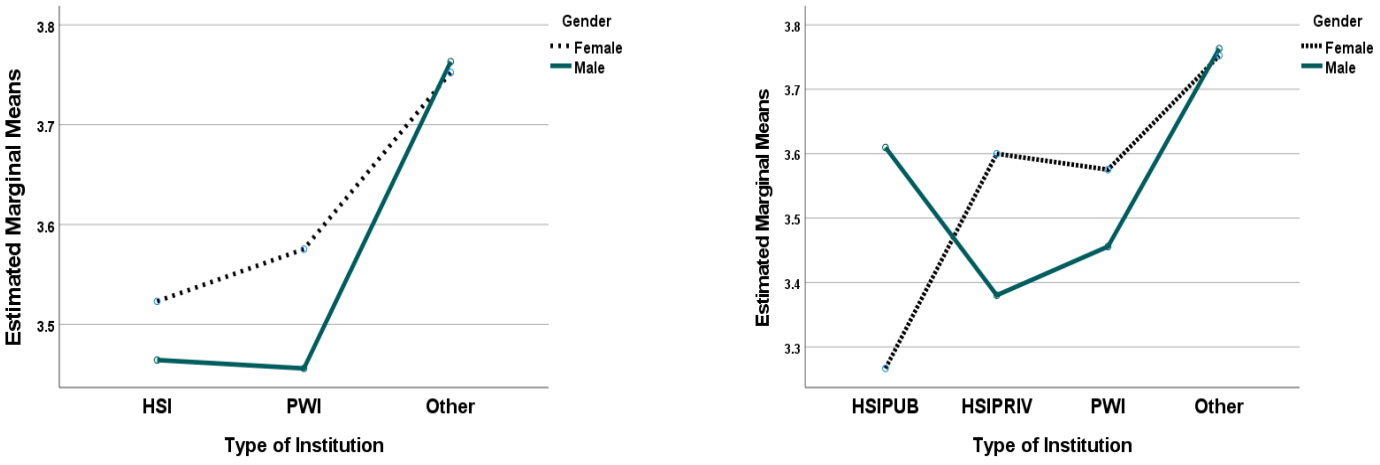
Table 3. HCA Overall Means across Institution Types and Self-Identified Gender

Institution Type	Mean (SD)	
	Female	Male
Overall	3.64 (.89)	3.54 (.83)
HSI (public + private)	3.52 (.92)	3.46 (.82)
HSI (public)	3.27 (.88)	3.61 (.83)
HSI (private)	3.60 (.93)	3.38 (.80)
PWI	3.58 (.85)	3.46 (.82)
Other (e.g., HEIs)	3.75 (.89)	3.76 (.86)

A two-factorial ANOVA of HCA ratings was performed across the institution types and self-identified gender. The assumption of normality was tested by examining the residuals (the difference between the observed and predicted values) and a review of skewness (-.23) and kurtosis (.09). Also, Levene's homogeneity of variance assumption was also satisfied [33],[34] [F (5, 671) = .62, p = .70]. There were no significant differences between self-identified females and males in their responses. While the intersection of gender and institution type had an effect on student's identification and subsequent rating of the HCA as shown in Figure 1a, it did not have a significant interaction (p =.72). However, there was a significant difference between the institution type (F = 6.25, df = 2, 671, p = .002) with a small effect size (partial η^2 = .02) and an observed power of 0.89. A posthoc Tukey HSD multiple comparison procedure suggested a significant difference in observed means between 'Other' institutions (M= 3.76, SD = .87) compared to HSIs (M = 3.49, SD = .85) and PWIs (M = 3.49, SD = .82).

An additional test, a two-factorial ANOVA, was conducted for different HSI institutions—namely public and private and were compared to PWIs and 'Other.' An assumption for normality was tested by examining the residuals and a review of skewness (-.23) and kurtosis (.09). Levene's homogeneity of variance assumption was also satisfied [33],[34] [F (7, 669) = .369, p = .92]. There were no significant differences between self-identified females and males in their HCA ratings. While the intersection of gender and type of institution had an effect on students' identification and HCA rating as shown in Figure 1b, it did not have a significant interaction (p =.24). As previously seen, there was a significant difference between the type of institutions [F = 4.50, df = 3, 669, p = .004] with a small effect size (partial η^2 = .02) and an observed power of 0.88.

Pairwise comparisons of estimated marginal means showed a significant difference in the HCA rating from the "Other" institutions. A posthoc Tukey HSD multiple comparison procedure was conducted and results suggest a significant difference in observed means between PWIs (M = 3.49, SD = .82) and Other institutions (M = 3.76, SD = .87) and Other institutions and private HSIs (M = 3.47, SD = .86).



(A) (B)

Figure 1: Main and interaction (intersectionality) effects for type of institutions (A: HSI, PWI, and Other; B: HSI-public, HSI-private, PWI, and Other) and self-identified gender. Estimated marginal mean scores signifies higher levels of HCA.

As the quantitative results suggest, and based on the institution type, there were significant differences in the way undergraduate engineering students responded to the six assumption statements (HCA). While not significant, self-identified females primarily endorsed a higher HCA rating compared to self-identified males. While this study also looked at the intersection of institution type and self-identified gender, there were no significant differences in HCA responses. However, there was a significant difference in the observed means for students from HSI private and PWIs compared to the Other group (primarily HEIs). HEIs appeared to have higher estimated means, suggesting higher levels of HCA. While the differences were so prevalent in HEIs, it is evident that not all students are identifying the HC at the same level. This suggests institution type-differences in HCA and supports that engineering students may recognize and reflect HC differently based on the structures they find themselves in [1],[35].

Qualitative Findings - Open-Ended Definitions of HC Amongst Students:

As with the quantitative results, open-ended responses to this question (see Table 1) were grouped by the different types of institutions. Regardless of institutional type comparisons (e.g., HSIs versus HSI public or private) or self-identified gender, there were four common themes identified: (a) Confirmation of Existence of HC; (b) Attribution of HC to Cognitive Elements; (c) Attribution of HC to Socio-Humanistic Elements; and (d) Refusal of Existence of HC. These themes were then integrated to HCA responses to identify the predominant assumption(s) (Table 1) that the students ascribed to in their definitions. This integration is presented in the discussion section.

(a) ***Confirmation of Existence of HC.*** Students identified HC based on the definition that was given by the developers of the vignette survey [12]. By doing so, students either re-stated the definition or selected aspects of the definition that stood out to them that may have helped

them identify a particular attribute of HC in the vignette. For example, students across all institutions identified HC to include rules, lessons, and expectations within an engineering curriculum. These groups of students may have chosen attributes within the definition or repeat the definition either due to a lack of nuanced language or a desire to not expend more time reflecting upon HC. More analysis is needed to tease these out in the future.

> *Hidden curriculum is a series of prejudged assumptions in a profession.* [HSI private, Self-Identified Male]
>
> *Stereotypes, beliefs, or ideas that are passed, shared, or taught in disguise because they seem the norm or they have been the norm for a long time.* [HSI public, Self-Identified Female]
>
> *A hidden curriculum is a side effect of schooling, "[lessons] which are learned but not openly intended" such as the transmission of norms, values, and beliefs conveyed in the classroom and the social environment*… [PWI, Self-Identified Female]
>
> *Hidden curriculum are lesson, values, and norms students unintentionally learn* [PWI, Self-Identified Male]
>
> *Hidden curriculum is the assumption that anything that is not technically related is not as important in engineering.* [Other, Self-Identified Female]
>
> *Hidden curriculum is a side effect of schooling, Lessons which are learned but not openly intended such as the transmission of norms, values, and beliefs conveyed in the classroom and the social environment.* [Other, Self-Identified Male]

(b) ***Attribution of HC to Cognitive Elements.*** In this theme, students defined HC within the scope of skills required in engineering or aspects that help them become a better engineer. Some expanded upon their learning experience in engineering to broaden their technical knowledge.

> *The concepts that all majors must learn that can applied in their respective fields, aside from classes and examinations.* [HSI public, Self-Identified Male]
>
> *Hidden curriculum are topics related to a class that even though they are not about the class, they further your knowledge in that field.* [HSI private, Self-Identified Female]
>
> *The way the class is structured, and the values set forth by a professor can instill impressions on students about what is important about engineering and what the goals are for being a good engineer in the future*. [PWI, Self-Identified Female]
>
> *Additional facts and details mentioned by the professor that they may think is interesting and useful information that may not be tested.* [Other, Self-Identified Female]
>
> *Hidden curriculum are those things that could help in engineering courses.* [Other, Self-Identified Male]

(c) ***Attribution of HC to Socio-Humanistic Elements****.* Responses focused on the need to include social awareness and acceptance of all cultures and contributions within formal engineering curriculum. Some responses within HSIs focused on *Hispanics* (a term written *verbatim* by the participants) and a possible explanation for this could be the vignette video portrayed two engineering professors one of whom self-identified as Hispanic.

> *Hidden curriculum includes the history (people/culture), social impact, or ideas that contribute to the field of engineering, but are not taught in a traditional classroom; Hidden curriculum are the topics discussed in classrooms that are not covered specifically in engineering but celebrate diversity.* [HSI public, Self-Identified Female]
>
> *An erroneous set culture that promotes a race-based, elitist "status" for engineers who are not part of a set "norm".* [HSI private, Self-Identified Male]
>
> *Assumptions or statements made about a subject that are implied but not explicitly stated. They convey societal norms and prejudices in an indirect way.* [PWI, Self-Identified Female]
>
> *Hidden curriculum are subliminal messages that seek to repress and ignore contributions by minorities in the mainstream*. [PWI, Self-Identified Male]
>
> *Hidden curriculum to me means having hidden agendas inside what is taught in engineering disciplines. For instance, purposefully leaving out examples of diversity and history when it doesn't fit the normal realm that a professor is used to.* [Other, Self-Identified Female]
>
> *Hidden curriculum is the unstated norm that exists within engineering institutions that marginalizes many aspects of the true diversity of engineering. Whether that is contributions from those of minority groups to engineering or recognizing diversity.* [Other, Self-Identified Male]

(d) ***Refusal of Existence of HC.*** The majority of the responses within this category came from PWIs, independent of self-identified gender. Most of students' responses focused on justifying the HC or stating that HC assumptions described in the UPHEME instrument (Table 1) don't exist. Furthermore, they indicated that there is an exaggeration of both racism or lack of diversity in engineering.

> *Is when somebody has their own agenda and encourages things with the purpose to get what he or she wants*. [HSI public, Self-Identified Male]
>
> *When professors incorporate topics of personal interest into their lesson plans even if it does not relate to the course material.* [PWI, Self-Identified Male]
>
> *A preconceived bias towards the field of engineering that may or may not be true regardless of its moral implications*; *Faking and over exaggerating racism or lack of diversity in engineering in order to make me feel bad that I am a white male*

engineering student. Sorry, but that's the way I was born. [PWI, Self-Identified Male]

I don't want to define something I don't think is a real issue. [PWI, Self-Identified Male]

From the qualitative findings, undergraduate engineering students, irrespective of gender and type of institution, identified HC as hidden and not directly communicated to them. Rather, they viewed HC as a 'necessary evil' for engineering education and formation. This was evidenced amongst PWI undergraduate engineering students, independent of self-identified gender, who almost unanimously refused the existence of HC, as found in prior and ongoing studies [7]-[10],[12].

Integrating Qualitative and Quantitative Findings

When integrating the quantitative and qualitative findings, results revealed that students predominantly rooted their definitions of HC in three assumptions (Table 1, assumption 2,5,6): (a) the central focus of engineering on the technical specifications rather than the socio-cultural considerations; (b) under-valuing of engineering "soft skills"; and (c) under-valuing of diversity in engineering. While their definitions of HC did not directly state these, based on the attribution to cognitive and socio-humanistic elements, it was apparent that their definitions reflected a level of relatedness to these topics. It was unclear, however, how much were these topics valued by the participants, which is beyond the scope of this project.

Furthermore, all participants confirmed a level of HCA by their provision of a definition to HC to the open-ended responses, even if at times they repeated the provided definition. It was also evident that some students opted to refuse the existence of this HC. This was primarily done by undergraduate students at PWIs.

Upon closer examination, students at PWIs predominantly rooted their definitions of HC in assumptions 1-2 (access and socio-cultural considerations in engineering) and 5-6 (undervaluing of soft skills and diversity in engineering). Among the elements described, these participants also indicated that the HC was either unimportant to them or stated that the HC was an over exaggeration of racism. These same participants also suggested that the HC was a professor's persuasion to believe what they believe in. One possible explanation to this refused acknowledgement of HC could be steeped in the way that engineering has traditionally been taught—to be technocentric, which often excludes the political, social, and societal roles of engineers [7],[22]. Additional work is needed to confirm if these views parallel that of graduate students and engineering faculty in our study.

Limitation

While this study only looked into undergraduate engineering students' HCA through various HC assumptions, it is limited in that the sample is not representative of other minoritized groups based on gender and race/ethnicity. For example, diversity is only limited to females and males for gender or race and ethnicity (e.g., Whites, Hispanicx, Latina/o/x/é, Chicana/o), or by select institutional types (e.g., HSI, PWI, HEI). While not anticipated in the original study, through

UPHEME we collected data from other institution types such as HEIs (representing over 50% of the sample). HSI private and PWI's significantly differed in their responses compared to HEIs. This is a group that needs further investigation but is outside the scope of this study.

Another limitation is that this study only looked at HCA for undergraduate engineering students and not graduate students and faculty. The ways in which HCA differ for other groups (e.g., graduate students, faculty) needs to be further investigated.

Finally, the findings from this work was a snapshot in time and may not fully reflect the evolution of ideas and experiences with engineering education and to the HC surrounding them [12]. The research group did conduct a follow-up qualitative study across the five institutions via professional development seminars. However, analysis of these findings are underway and not within the scope of this study.

Final Thoughts

In addition to contributing to the knowledge base of HC in engineering, this study has presented the HCA for undergraduate engineering students in HSIs and non-HSIs. The findings reflect the varied influence the intersection of institutional type and gender may have on students' acknowledgement of HC. It is important that engineering faculty and institutions develop interventions—not just help them identify HC, to train administrators, faculty, and students to see the HC so that these issues can be structurally addressed. As stated in prior work [12], the HC is not necessarily negative and if used in a positive manner can help institutions to promote inclusivity, recognition, acceptance, and equity within and beyond the community of engineering practice and research. However, none of this can happen unless HC is recognized.

Acknowledgement

This material is based upon work supported by the National Science Foundation (NSF) No. EEC-1653140 and 2123016 given to the second author. Any opinions, findings, and conclusions or recommendations expressed in this material do not necessarily reflect those of the NSF. We want to give a special thanks to the institutional liaisons, Dr. Hector Cruzado, Dr. Sindia Rivera-Jimenez, Dr. Heather Shipley, Dr. Kimberly Cook-Chennault, and Dr. Paul Barr who assisted us with collecting participant data in the first stage of sampling. We also want to thank the participants for sharing their experiences with us and the readers of this work.

References

[1] I. Villanueva, M. Di Stefano, L. Gelles and K. Youmans, Hidden curriculum awareness: a qualitative comparison of engineering faculty, graduate students, and undergraduates, World Engineering Education Forum, Albuquerque, NM, pp. 1–6, 2018.

[2] K.L. Tonso, "Plotting something dastardly": Hiding a gender curriculum in engineering", in The hidden curriculum in higher education (pp. 165-184), 2001, Routledge.

[3] S.K. Erickson, "Engineering the hidden curriculum: How women doctoral students in engineering navigate belonging", Arizona State University, 2007.

[4] I. Villanueva, I. CAREER: Advocating for engineering through hidden curricula: A multi-institutional mixed method approach, 2017. https://nsf.gov/awardsearch/showAward?AWD_ID=1653140&HistoricalAwards=false

[5] M. Polmear, A. Bielefeldt, D. Knight, C. Swan, & N. Canney, "Hidden Curriculum Perspective on the Importance of Ethics and Societal Impacts in Engineering Education", 2019 ASEE Annual Conference & Exposition Proceedings. https://doi.org/10.18260/1-2--32887.

[6] S.C. Rea, & K. Shiekh, & Q. Zhu, & D. Nieusma, "The hidden curriculum and the professional formation of responsible engineers: A review of relevant literature",2021 in ASEE Conference Proceedings. Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. https://peer.asee.org/37866.

[7] I. Villanueva, L. Gelles, M. Di Stefano, B. Smith, B., R.G. Tull, S.M. Lord, L. Benson, A.T. Hunt, D.M. Riley, & G.W. Ryan, "What does hidden curriculum in engineering look like and how can it be explored? ", 2018, Proceedings of the American Society of Engineering Education Annual Conference & Exposition, Minorities in Engineering Division, June 24-27, 2018, Salt Lake City, UT, Paper #21884, 1-16.

[8] I. Villanueva, L. Gelles, K. Youmans, & M. Di Stefano, "Hidden curriculum awareness: A comparison of engineering faculty, graduate students, and undergraduates. World Engineering Education Forum, 1–6, 2018

[9] I. Villanueva, T. Carothers, M. Di Stefano, & M.T.H. Khan, "'There is Never a Break': The hidden curriculum of professionalization for engineering faculty", Education Sciences, vol. 8, issue 57, pp.1-21, 2018.

[10] I. Villanueva, R. Revelo, A., Mejia, J. Mejia. "Professional development of Latinx engineers on hidden curriculum: An exploratory study", IEEE Frontiers in Education Conference, 1–5, 2019. https://ieeexplore.ieee.org/abstract/document/9028632/?casa_token=IlEutod0MsYAAAAA:56av6jlwQiST1cOOXdRMfi6yjeyFAjDszVw6TwcC1ruk5FSeOSdB7wa_8Ga_3_3DMNhoRj5h

[11] L. A. Gelles, K. L. Youmans, and I. Villanueva, "Sparking action: How emotions fuel or inhibit advocacy around hidden curriculum in engineering," in SEFI 47th Annual Conference: Varietas Delectat... Complexity is the New Normality, Proceedings, 2020, pp. 1566–1575.

[12] I. Villanueva, M. Di Stefano, L. Gelles, K. Youmans, & A. Hunt, "Development and assessment of a vignette survey instrument to identify responses due to hidden curriculum among engineering students and faculty", International Journal of Engineering Education, 36(5), 1–21, 2020.

[13] I. Villanueva Alarcón, & V. Sellers, "Faculty development in the Third Space: Influence of hidden curriculum amid engineering educators", in S. Linder, C. Lee, & K. High (Eds.), *Handbook of STEM Faculty Development* (In-Press), 2021.

[14] V.B. Sellers, & I. Villanueva Alarcón, "What strategies do diverse women in engineering use to cope with situational hidden curriculum?" ASEE Virtual Annual Conference, 2021. https://peer.asee.org/38051

[15] R. Paul, L. Behjat, & R. Brennan, "Using individual-based modeling to better understand the hidden curriculum of engineering", Proceedings of the Canadian Engineering Education Association (CEEA), 2021.

[16] R. Tormey, I. Leduc, S. Isaac, C. Hardebolle, C., & I.V. Cardia, "The formal and hidden curricula of ethics in engineering education", Proceedings of the 43rd Annual SEFI Conference. https://www.sefi.be/wp-content/uploads/2017/09/56039-R.-TORMEY.pdf, 2015

[17] T. Parsons, T., "Social systems and the evolution of action theory (First)", 1077,Free Press.

[18] J.H. Turner, "Herbert Spencer: A renewed appreciation (Vol. 1)", 1985, SAGE Publications, Incorporated.

[19] J. Urry,"Sociology beyond societies: Mobilities for the twenty-first century", 2012, Routledge.

[20] I. Villanueva Alarcón, C.E. Sunny, & J. Kesse, "Quantifying the Intersectional Dynamics of Hidden Curriculum Pathways in STEM", *Journal of Engineering Education,* (In Preparation), 2022

[21] R. Pekrun, R. &L. Linnenbrink-Garcia, (Eds.). International Handbook of Emotions in Education. Routledge. https://doi.org/10.4324/9780203148211, 2014.

[22] A. Skelton, "Studying Hidden Curricula: Developing a Perspective in the Light of Postmodern Insights", Curricular.Studies, vol.5, no.2, pp.177-193, 1997.

[23] J.W. Creswell, "Basic characteristics of mixed methods research, A concise introduction to mixed methods research (pp. 1- 11)", 2021. SAGE publications.

[24] J. Roberts, "The ''hyper-rationality'' trap", Information Systems and Operations Research, 17(1), pp. 73–75, 1979

[25] D. Riley, "Engineering and social justice", Synthesis Lectures on Engineers, Technology, and Society, 3(1), pp. 1–152, 2008.

[26] D.A. Benett, "How can I deal with missing data in my study?," Australian New Zealand Journal of Public Health, vol. 25, no. 5, pp. 464–469, Oct. 2001.

[27] J.W. Creswell and V. L. Plano Clark, “Designing and Conducting Mixed Methods Research”,2017, SAGE Publications Inc. SAGE Publications.

[28] S. Van Buren, “Flexible Imputation of Missing Data,” 2012, Boca Raton, FL: CRC Press.

[29] M.H.C. Lai, “Missing Data”, [unpublished], Mar 7, 2017, Educational Studies, QMRM, University of Cincinnati.

[30] IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp

[31] J. Saldaña, “The coding manual for qualitative researchers,” 2016. London: Sage.

[32] H.N. Boone and D.A. Boone, “Analyzing Likert Data”, Journal of Extension, vol. 50, no. 2, Apr. 2012.

[33] H. Levene, “Robust tests for equality of variances. Contributions to probability and statistics,” Essays in honor of Harold Hotelling, pp. 279-292, 1961.

[34] D. Hahs-Vaughn, D. & R. Lomax, “An introduction to statistical concepts”, 2013, London, Routledge.

[35] F. D. Gilliam Jr and S. N. Bales, “Strategic framing analysis: reframing America’s youth”, Social Policy Report: Giving Child and Youth Development Knowledge Away, 15(3), pp. 3–14, 2001.