

University of Massachusetts Amherst

**ScholarWorks@UMass Amherst**

---

College of Education Faculty Publication Series

College of Education

---

2018

## **“There Is Never a Break”: The Hidden Curriculum of Professionalization for Engineering Faculty**

Idalis Villanueva

Taya Carothers

Marialuisa Di Stefano

Tarique Hasan Khan

Follow this and additional works at: [https://scholarworks.umass.edu/education\\_faculty\\_pubs](https://scholarworks.umass.edu/education_faculty_pubs)

---

Article

# “There Is Never a Break”: The Hidden Curriculum of Professionalization for Engineering Faculty

Idalis Villanueva <sup>1,\*</sup>, Taya Carothers <sup>2</sup>, Marialuisa Di Stefano <sup>3</sup> and Md. Tarique Hasan Khan <sup>4</sup>

<sup>1</sup> Department of Engineering Education, College of Engineering, Utah State University, Logan, UT 84322, USA

<sup>2</sup> International Office, Advising Services, Northwestern University, Evanston, IL 60208, USA; taya.carothers@northwestern.edu

<sup>3</sup> Department of Teacher Education and Curriculum Studies, University of Massachusetts Amherst, Amherst, MA 01003, USA; marialuisadi@umass.edu

<sup>4</sup> Department of Engineering Education, College of Engineering, Utah State University, Logan, UT 84322, USA; tariquehasan@aggiemail.usu.edu

\* Correspondence: idalis.villanueva@usu.edu

Received: 1 August 2018; Accepted: 20 September 2018; Published: 22 September 2018



**Abstract:** The purpose of this exploratory special issue study was to understand the hidden curriculum (HC), or the unwritten, unofficial, or unintended lessons, around the professionalization of engineering faculty across institutions of higher education. Additionally, how engineering faculty connected the role of HC awareness, emotions, self-efficacy, and self-advocacy concepts was studied. A mixed-method survey was disseminated to 55 engineering faculties across 54 institutions of higher education in the United States. Quantitative questions, which centered around the influences that gender, race, faculty rank, and institutional type played in participants' responses was analyzed using a combination of decision tree analysis with chi-square and correlational analysis. Qualitative questions were analyzed by a combination of tone-, open-, and focused-coding. The findings pointed to the primary roles that gender and institutional type (e.g., Tier 1) played in issues of fulfilling the professional expectations of the field. Furthermore, it was found that HC awareness and emotions and HC awareness and self-efficacy had moderate positive correlations, whereas, compared to self-advocacy, it had weak, negative correlations. Together, the findings point to the complex understandings and intersectional lived realities of many engineering faculty and hopes that through its findings can create awareness of the challenges and obstacles present in these professional environments.

**Keywords:** hidden curriculum; engineering; faculty; professionalization; mixed-methods

## 1. Introduction

The goal of this research is to explore how engineering faculty understand hidden curriculum (HC) in higher education settings and their overall reactions and responses to the prevalence of HC in engineering. HC is defined as the unwritten, unofficial, unintended values, lessons, and perspectives that are present in an academic settings and work environments [1–8]. Since the exploration of HC in engineering is very limited [4–6], this special issue exploratory study aims to expand upon the existing knowledge-base about HC to elucidate the mechanisms that faculty use to internalize and communicate their thoughts on this phenomenon.

This study was conducted to help shed light on the lived realities of engineering faculties across several institutional types and is intended for different administrative entities, faculty, and students in Colleges of Engineering, in order to create awareness of the challenges and obstacles that many engineering faculty face. It is the hope of the authors that those who read this manuscript can be

inspired to start a conversation about working together to develop healthy and equitable working environments for all.

## 2. Theoretical Framework

### 2.1. Hidden Curriculum (HC)

In school settings, curriculum can come in many forms: (a) formal curriculum; (b) informal curriculum; (c) null curriculum; and (d) hidden curriculum [7,8]. The formal curriculum consists of a set of explicitly stated requirements (e.g., rubric) that serve as official guidelines for how to engage with and evaluate the quality of work of students and teachers [2,5–18]. The informal curriculum consists of learning that occurs via personal interactions in the classroom or work spaces [7–9,15–18]. The null curriculum represents the elements that are not taught in a classroom due to mandates from higher authorities, a teacher's lack of knowledge or comfort-level about a topic, or stem from deeply ingrained biases and assumptions about a topic. For example, teaching genetics to introduce topics like evolution continue to be controversial topics that some educators in science classrooms opt to not discuss [19]. Hidden curriculum (HC) represents how particular assumptions, beliefs, values, or attitudes manifests themselves implicitly and inadvertently in schooling, learning, and professional environments [1–18].

HC represents the implicit “attitudes, knowledge, and behaviors, which are conveyed or communicated without aware intent” ([20], p. 125). For example, if an instructor decides to not emphasize a topic for an exam, a student may perceive that this concept is not important to learn. Thus, HC functions at the unconscious, nonverbal spaces of the classroom [7,8] and professional settings [15–18].

Similarly, in the classroom, students do not just learn what is being formally presented in the course but also collect other ‘hidden’ lessons in the process. It is believed that the human mind can process 80% of explicit information and content in an unconscious manner [7]. Over time, these explicit sources gradually slip beneath the realms of conscious reflection to become a norm that is part of a formalized system [7,8]. Thus, the “space between the official and unofficial, the formal and the informal, the intended and the perceived” ([7], p. 35) becomes the realm where HC lies [1–8].

HC has been used in many disciplines including education, psychology, business, and medicine [9–18] as a strategy to uncover and predict potential issues, that if not attended on time, can lead to dire consequences (e.g., drop-out). While HC traditionally has been tied to negative issues, if used and attended to appropriately, can be used to yield opposite outcomes in students, staff, or faculty (e.g., higher performance; motivated learners and workers) [1–8].

To explore HC, researchers rely on metaphors, vignettes, counter-claims [2,7,11,12,14,16] and ethnographic approaches [14] to robustly analyze the values, perspectives, and beliefs of individuals involved in a learning or working environment. Since HC is contextual and situational, there is also a need to explore these issues from a disciplinary and institutional standpoint as systematic and formalized rules and procedures can vary [1–8]. From a more granular perspective, since HC can be very distinct, it is also important to consider how an individual processes internally these implicit cues [4]. To our understanding, no work has attempted to explore the latter, and in particular for engineering [4].

### 2.2. HC Mechanisms for Engineering

This work builds upon an initial study from the authors calling for the need to explore more holistically and mechanistically how individuals collect and process these ‘hidden’ messages in learning and working environments (Villanueva et al., 2018). Earlier work conducted by Authors [4,21] suggested that HC can consist of 16 or more distinct factors to inform the processing of these ‘hidden’ messages although four of them appear more prevalent: (a) awareness; (b) emotions; (c) self-efficacy; and (d) self-advocacy [4,21]. These will be explained more below.

### 2.2.1. Awareness of the Presence of HC

Awareness of the presence of HC is an important step for an individual to recognize and reflect upon what is being presented and what is being communicated within their surrounding environment [22–25]. Recent advances in social and cognitive psychology, particularly in the area of metacognition (i.e., an individual's belief about their mental state) [26] has expanded our understanding about what constitutes consciousness [24,25]. The term 'conscious' generally refers to a person directly *seeing, knowing* or *feeling* a particular mental content rather than having to indirectly infer upon it [23–25]. Awareness is a sub-component of consciousness where an individual recollects internally an experience and represents it externally (e.g., communication) [26–28]. Depending on the level of representation present, an individual can move into the realm of what is not cognizant (unconscious) or misrepresented (meta-consciousness) [24,25]. Regardless of the level of awareness a person may have about an issue, these cannot be brought up to full consciousness unless they are internalized first.

### 2.2.2. Emotions to Guide HC Processing

Internalization of an experience typically occurs through an individual's emotions. Emotions assist individuals in narrowing down the variables that are of importance and guide individuals to make decisions for several scenarios [18]. Emotions are important to the learning and socialization process of individuals [29] and serve to explore the influences that several forms of subliminal stimuli can have in their communicated responses [24]. In academic settings, emotions consist of many coordinated processes that involve affective, cognitive, motivational, expressive, and peripheral subsystems that are intertwined [29].

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 [29] whereas negatively activated emotions (e.g., anger) may result in low levels of cognitive processing [29].

Finally, emotions contribute to how a person learns, perceives, decides, responds, and problems solve [29]. In the context of HC, emotions can help cue to a person how 'hidden' spaces of expressions, glances, gestures, interest, frustration, and other similar observations become evident within a given context or environment [4,21].

### 2.2.3. Self-Efficacy Regulates Emotions

At the same time, emotions cannot occur unless a person *believes* that they are able to experience or allow oneself to experience emotions such as joy, anger, pride, etc. [30,31]. Thus, self-efficacy or an individual's beliefs on their ability to ameliorate adverse emotional states [32] is believed to regulate emotions. To our understanding, no work has been conducted to explore how self-efficacy regulates emotions needed to process HC.

### 2.2.4. Self-Advocacy is Guided by Self-Efficacy

In turn, self-advocacy influences how an individual takes control over their own motivation, behavior, and social environment [33,34]. As such, actions such as self-advocacy or an indication of a person's willingness to take action and speak up about a matter to improve their quality of life [35] cannot occur. To our understanding, no work has been conducted to explore how self-advocacy is guided by the self-efficacies that tie to emotions and HC awareness.

### 2.2.5. Integrating the Four Factors to Explore HC Mechanisms

Together, the authors posit that these four constructs can serve as a baseline by which to understand more holistically and mechanistically how an individual recognizes, reacts to, and gain abilities to execute control over their own learning or professional environment via HC. To our understanding, no research study has attempted to explore HC mechanisms nor in the context of

engineering education. Both elements represent a novel approach towards achieving excellence in engineering education, the focal point of this special issue.

### *2.3. Professionalization in Engineering: A Type of Formalization of HC*

Since HC involves the transmission of implicit messages in learning, teaching, and professional spaces [15–18,36,37], it is integral to understand how aspects of formalization [6,7] could slip beneath the realms of conscious reflection to become a norm [7]. As with any profession, the origins of any career path was once guided by a set of beliefs, values, and attitudes that over time, became a norm [36–38]. These norms can be represented in many ways, but one prevalent form is professionalization [38].

Within academia, the professionalization of faculty in higher education becomes the primary system by which lecturers, professors, and researchers rely on to understand how to navigate their academic environments [38–43]. Abbott [39] suggests that professions, in general, carries three major traditions: (a) traits of professions like cultures (e.g., what professionals in this field represent, and whom they associate with); (b) establishment of a formal education (e.g., licensing and accreditation) [40]; and (c) mechanisms to achieve and maintain a privileged position [41]. Thus, every professional discipline includes a different set of formalized norms and practices that uniquely characterizes their profession [38–41]; engineering is not the exception [44–46].

Professionalization of engineering centers around the intent to constantly adapt to the “ever-changing needs of the market, the emergence of interdisciplinary projects, the increasingly complex social and systemic paradigms” ([44], p. 639). Ironically, the literature suggests that engineering education does not parallel this professional intent as its culture and environments have not changed in decades [45,46] and effects due to these causes have resulted in a stagnant and severe underrepresentation of women and other underrepresented groups [47–50]. Thus, it appears that HC may be present in some of these issues and discrepancies, particularly for teaching and learning spaces where faculty are at the center.

For this work, we will focus primarily on engineering faculty, as these individuals are uniquely positioned in their engineering learning environments to serve as change agents if issues of HC are identified. Additionally, since HC is contextual, it will be important to understand how values, beliefs, and attitudes may change based on the institutional type (e.g., Tier 1, Tier 2) as well as other categorical variables such as race, gender, and faculty ranks (e.g., lecturers, assistant professors, full professors). Thus, this work does not aim to put any processes of professionalization in a negative light but rather through faculties’ approvals or disapprovals of the HC presented to them, provide a more rigorous and mechanistic understanding of potential issues that may be present in the education and professionalization of engineering.

## **3. Methods**

The research project presented in this manuscript is part of a more comprehensive and extended mixed-methods research that explored the HC perspectives of engineering undergraduates, graduates, and faculty [4,21]. For this study, we focused solely on engineering faculty, as through their voices, HC can be unveiled and more faculty can be positioned to serve as change agents for their students. All items in this study were conducted by adhering to ethical standards and treatment of human subjects as required by the Institutional Review Board (IRB) of the home institution of the first author.

### *3.1. Research Design*

This work uses a complex, mixed-method experimental intervention design [51,52] that incorporates a quasi-experimental quantitative design with qualitative data that is combined in a convergent manner. For this study, integration of the qualitative and quantitative findings of the design occurred in the data analysis and interpretation phases of the work [53]. Additionally, a primary emphasis was placed on the quantitative elements of the study (denoted by the higher caps, ‘QUAN’)

and a secondary emphasis was given to the qualitative components of the work (denoted by the lower caps, 'qual') [51,52].

### 3.2. Research Questions

The three central hypotheses (H1, H2, and H3) for the QUAN elements of the study are:

**H1.** *Engineering faculty will recognize HC in their fields regardless of race, gender, rank, and institutional type.*

*Rationale:* Given that the literature points to the relatively stagnant culture of engineering [44–50], it is possible that the cultural norms, beliefs, values, and attitudes continue to pervade regardless of other intersectional identities (e.g., race, gender).

**H2.** *Changes among institutional types (e.g., Tier 1 compared to Tier 2) will result in a decreased recognition of HC mechanisms among engineering faculty, regardless of race and gender, when counter-claims of the field of engineering is presented.*

*Rationale:* Within institutions where tenure is a primary focus [38–41], professional elements such as research and teaching may make faculty more prone to experience the influences of HC.

**H3.** *Changes among professional faculty ranks (e.g., lecturer versus associate professor), regardless of race, gender, and institutional type will result in an increased presence of HC mechanisms among engineering faculty when counter-claims of the field of engineering is presented.*

*Rationale:* In parallel to the institutions' research focus, faculty responsibilities may be more geared towards research [38–41] and these focuses on their professions may lead to a higher internalization of HC.

The main research question (RQ) used for the qual portions of this work was:

**RQ1.** *What are the central messages around the professionalization of engineering that the faculty convey?*

### 3.3. Participants

The participants were 55 engineering faculty, out of 393 total participants that included undergraduates, graduates, postdocs, and faculty [4,21], working or studying across 54 higher education institutions in the United States and Puerto Rico. The breakdown of the institutional types assessed and regions are summarized in Table 1. Note that while Carnegie classification was used as a guide to label the institutional types [54] some were clustered (e.g., community colleges) to allow for statistical comparisons among the groups. Additionally, to protect the anonymity of the participants, no institution name was included.

**Table 1.** Summary of institutional types where engineering faculty were employed.

Institutional Type (Tier Label)	Carnegie Classification Description	% Faculty Participants
R1 (Tier 1)	Doctoral universities: highest research activity	48%
R2 (Tier 2)	Doctoral universities: higher research activity	13%
R3 (Tier 3)	Doctoral universities: moderate research activity	9%
M1-M3 (Tier 4)	Master's Colleges and University: All Programs Sizes	15%
B1-B3 (Tier 5)	Bachelor Colleges and Community Colleges: All Program Sizes and Types	15%

Participants were recruited using purposeful sampling [55,56] through email and posts on social media channels connected to engineering professional organizations (e.g., Society for Women Engineers, Society of Hispanic Professional Engineers, and American Society of Mechanical Engineers) as well as LinkedIn and Facebook. The inclusion criteria were: (a) current engineering faculty member at a higher institution in the United States; and (b) response to our call. The exclusion criteria were: (a) retired faculty in engineering; (b) engineering faculty who were not in an institution of higher

education in the United States; and (c) practicing engineers in industry. For the latter, we had some international individuals and engineers from industry who responded to the survey but, due to the nature and scope of the work, these were excluded from analysis.

A summary of the ranks (e.g., lecturers, assistant professors) of the engineering faculty participants are described in Table 2. Note that adjuncts and lecturers were considered one type of rank as their primary roles are teaching and not research. Furthermore, a racial and gender breakdown of the engineering faculty participants are summarized in Tables 3 and 4, respectively, as we were interested in understanding if individual intersectional identities based on race and gender could influence these HC mechanisms differently. Note that some of the faculty self-reported as being multi-racial as shown in Table 3.

**Table 2.** Summary of ranks of engineering faculty.

<b>Rank</b>		
Adjunct and Lecturers	16	29%
Assistant Professors	15	27%
Associate Professors	11	20%
Full Professor	13	24%
<b>Total</b>	<b>55</b>	

**Table 3.** Summary of race of engineering faculty.

<b>Race</b>		
White	39	60%
Hispanic	10	15%
Asian	8	12%
Black/African American	3	5%
Two or more	5	8%
<b>Total</b>	<b>65</b>	

**Table 4.** Summary of gender of engineering faculty.

<b>Gender</b>		
Female	28	51%
Male	26	47%
Non-binary/third gender	1	2%
<b>Total</b>	<b>55</b>	

### 3.4. Survey Items

The survey items to be discussed in this manuscript are part of a larger survey, whose validation process was discussed elsewhere [4,21]. The validated instrument consists of 10 demographic questions, 24 Likert-scale items (six items per sub-scale: awareness, emotions, self-efficacy, and self-advocacy) and five qualitative questions about participants' views about engineering and HC in engineering and a video vignette. The full instrument has a Cronbach alpha score of 0.70 and sub-scale scores of 0.70 for HC awareness, 0.71 for emotions, 0.82 for self-efficacy, and 0.84 for self-advocacy [21].

The video vignette was created from a systematic review of the engineering education literature before its creation and inclusion in the survey as described elsewhere [4,21]. To summarize the video briefly, the content exposed participants to the dynamics involved during an engineering course preparation by two instructors and the interactions in engineering classrooms between students and these two faculty members. Video elicitation was used as a social science technique to garner participant awareness about a topic [21,57]. In this video, issues of gender dynamics and race were highlighted as the literature suggests a severe underrepresentation of these groups in

engineering [44–50]. Furthermore, it is important to mention that while the video may have appeared biased at a glance, the video was representative of a systematic synthesis of the literature (written in script form) of the primary cultures and environments of engineering education [44–50].

Since rigorous analysis of HC requires strategies built upon counter-claims [7], the topics and scopes selected for the video were deemed appropriate to the scope of the work and its fictitious nature was indicated to the participants. The video also went through a rigorous process of validation before it was added to the instrument [21] and its final Cronbach alpha score was found to be 0.87 across the original 393 participants [21]. In a similar vein, the HC statements selected for this instrument represented the video closely as well as the systematic review of the engineering education literature [4,21,44–50]. The full instrument and video links are expected to be released in the near future.

Based upon prior findings and throughout the survey validation process, the authors found that many participants could not recognize HC [21]. As such, it was deemed necessary to carefully place the items of the survey in a way that participants could recognize and reflect upon the HC sub-scales to minimize any potential “mental shortcuts” they may have used to make sense of a new concept or phenomenon ([58], p. 4). Additionally, since framing has an influence over the interpretation of meanings and its connections to ideas and beliefs [58], the research team wanted to make sure its placement would minimize potential variations in the understanding of this phenomenon amongst a diverse set of populations [21].

To summarize and for the purpose of this special issue exploratory study, the survey participants were part of the original participants needed for this survey validation. Participants who took this version of the survey saw the following sequence: (a) demographic questions; (b) qualitative questions; (c) video vignette; (d) video character question; (e) HC awareness questions; (f) emotions questions; (g) self-efficacy questions; and (h) self-advocacy questions. This study focuses primarily on participants’ responses to the last four sub-scales and the qualitative questions.

Since HC requires that participants recognize the phenomenon [4,21], a definition of HC was provided based upon what has been identified in the literature [1–8]. Furthermore, to facilitate faculty participants’ understanding of HC, the terms “examples”, “agree”, “disagree”, and “statement” were used in the framing of the question to convey to participants that they had a choice and opinion that was valued in their responses. A description of one of the sub-scales (HC awareness) is included in Table 5.

**Table 5.** HC assumption statements used for this study.

<b>Instructions:</b>	
Hidden curriculum (HC) refers to the unwritten, unofficial, and often unintended lessons, values, and perspectives learned in an academic environment. We identified the following six examples of the hidden curriculum in this video. Read each statement. Do you agree or disagree with each statement ( <b>Yes = I agree, this is HC; No = I disagree, this is not HC</b> )?	
HC #1	Senior faculty in engineering (e.g., tenured professor) deserve higher status, voice, and have more influence than engineering junior faculty.
HC #2	The ultimate goal of an engineering degree is to get a well-paying job.
HC #3	Engineering education is harder, more time-consuming, and expensive because it has a direct impact on safety.
HC #4	Not everyone can be an engineer.
HC #5	To belong to the engineering community, your personality must fit in with everyone else’s (e.g., technically-driven, efficient, and assertive)
HC #6	Engineering instructors care more about the technical concepts and equations rather than the individual student’s success.

Note that for the other sub-scales (emotions, self-efficacy, and self-advocacy), the same six HC statements were used in an attempt to identify potential associations between the four factors. A summary of the presentation of the other sub-scales is provided in Table 6.

**Table 6.** Modified summary of instructions and Likert-scale descriptions for the other sub-scales in the instrument for this special issue study.

Sub-Scales	Instructions	Likert Scale Response Description
Emotions	What <b>emotion</b> would best describe your overall reaction to each statement ( <b>choose from the list</b> )? Is this overall emotion <b>positive</b> or <b>negative</b> for you? You can also indicate if this emotion is both positive and negative, or neither one nor the other.	'1'—I felt positive about this statement '2'—I felt negative about this statement '3'—I felt both positive and negative about this statement '4'—I felt neither positive, no negative about this statement
Self-efficacy	<b>Self-efficacy</b> is your belief in your ability to succeed in specific situations or accomplish a task. Rate your <b>confidence</b> (self-efficacy) in succeeding if placed in a similar situation to the statements provided.	'1'—I am not at all confident that I can succeed in a situation similar to this '3'—I am somewhat confident that I can succeed in a situation similar to this '5'—I am very confident that I can succeed in a situation similar to this
Self-Advocacy	<b>Self-advocacy</b> is the ability to speak or act on your own behalf to improve your quality of life, effect personal change, or correct inequalities. Rate your <b>willingness</b> to <b>advocate</b> for yourself if placed in a similar situation to the statements provided.	'1'—I am not at all willing to advocate for myself in situation similar to this '3'—I am somewhat willing to advocate for myself in situation similar to this '5'—I am very willing to advocate for myself in situation similar to this

For the emotions sub-scale, participants were provided with a list of 17 emotions as recommended by Pekrun and colleagues [29] and DeCuir-Gunby and colleagues [59]. Additionally, one of the valence dimensions (positive/negative) was asked. The results of this study focus on the latter (positive/negative valence). Also, participants were given the choice to choose “neither” or “both” to convey the possible and complex nature of emotions to different contexts and situations [29]. For the self-efficacy sub-scale, participants were asked to rate their confidence in their ability to succeed if placed in a similar situation to the provided HC statement. Terms like “confidence” and “success” were emphasized to convey the definition provided as well as help them contextualize that HC may guide coping strategies based upon their individual beliefs and perceptions. Finally, for the self-advocacy sub-scale, terms like “willingness” and “advocate” were used to convey to participants that they are in full control of their actions and approaches to situations similar to the provided example HC statements.

### 3.5. Data Preparation and Analysis

#### 3.5.1. QUAN Data Preparation

Pre-processing of data was first required to make it analyzable and to account for any missing values or text entries. All the blank spaces were filled by a category labeled as “No Response (NR)” accompanied by a numerical value. In a similar fashion, all other categorical responses, including demographic information (e.g., gender, race) were assigned a numerical value as shown in Table 7.

**Table 7.** Representative categorical participant responses that were assigned numerical values.

Gender	Race	Institution Type	Faculty Rank	HC Awareness	Emotions	Self-Efficacy and Self-Advocacy
Female = 1	White = 1	Tier 1 = 1	Adjuncts/	No = 0	Negative = 0	'1' = 1
Male = 2	Hispanic = 2	Tier 2 = 2	Lecturers = 1	Yes = 1	Positive = 1	'2' = 2
Third Gender = 3	Black = 3	Tier 3 = 3	Assistant Professor = 2	NR = 2 (No response)	Neither = 2	'3' = 3
	Asian = 4	Tier 4 = 4	Associate Professor = 3		Both = 3	'4' = 4
		Tier 5 = 5	Full Professor = 4		NR = 4 (No response)	'5' = 5

#### 3.5.2. Quantitative Data Analysis: QUAN

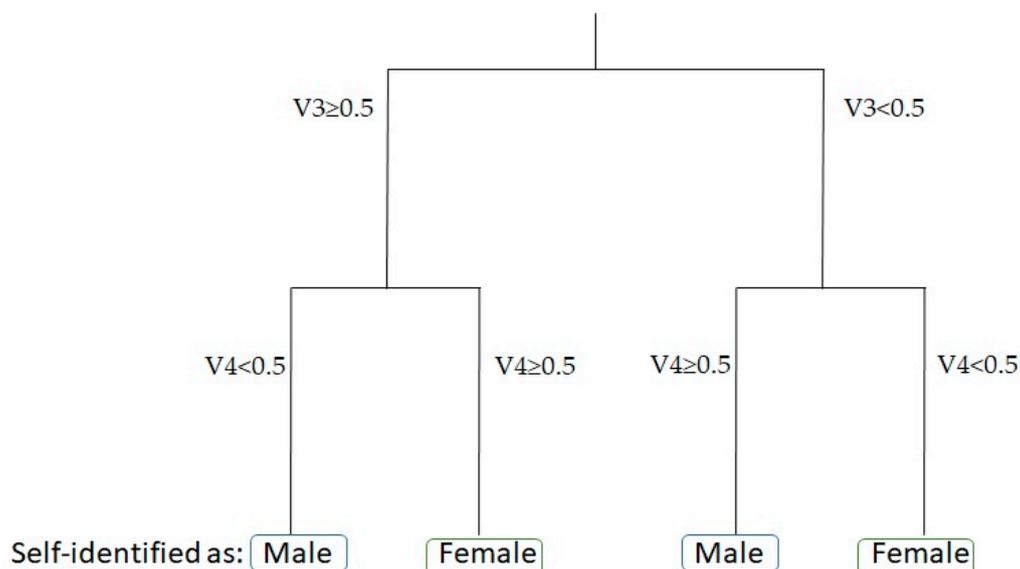
##### Advanced Machine Learning: Decision Tree Analysis

For quantitative analysis, the research team opted to use a new approach in their lab: advanced machine learning (AML). AML allows researchers to take a wide array of responses and using

algorithms, develop an automated and unbiased way to identify the likelihood of an influence on participants' response [60]. For similar study designs to ours, AML has used small and extendable (not a static or fixed) datasets to help classify what factors and sub-factors are predominant among participant responses [60].

It is important to note that although the dataset consists of only 55 participants, each participant yielded responses to four factors (awareness, emotions, self-efficacy, and self-advocacy) that were classified as six sub-factors (HC statements) and whose variations in sub-factor response (e.g., valence options; lists; Likert-scale entries) were different. As such, the nature of our dataset can be limited in its analysis through traditional statistical methods as oftentimes, these approaches are deficient in their ability to uncover the inter-relationships of varied dependent and independent variables [61]. Furthermore, through this technique, the researchers could consider in an unbiased and automated manner, how a wide array of intersectional demographics contributed to participants' responses. Hence, at a minimum, the dataset consisted of 24 independent factors/variables/features to analyze (e.g.,  $24 \times 55$  participants = 1320 minimum data points).

Within AML, a decision tree (DT) analysis was used [62–64]. DT was used in this study to understand the relational aspects between the factors, sub-factors, and specified categorical variables (i.e., gender, race, faculty rank, institution type). Decision trees include a feature (attribute), a link to each feature (branch), and a representative decision (rule) that represents an outcome (categorical or continuous value) [62–64]. For this study, a classification and regression tree (CART) algorithm was used to divide the factors, sub-factors, and variables to identify decision rules that can denote the relative importance or predominant influence of a variable. For CART, HC awareness consisted of six labels (v1–v6). Emotions had six labels starting from v7 to v12. In a similar fashion, variables are arranged for self-efficacy (v13–v18) and self-advocacy (v19–v24). A representative decision tree is shown in Figure 1 where the influence of gender over the factor HC awareness was found for the third (v3) and fourth (v4) HC example statements from Table 5. This same process was repeated for all the factors.



**Figure 1.** Decision tree to understand the influence of gender over HC awareness.

The DT example provided in Figure 1 shows how a decision tree works. In this example, a decision tree was used to identify the influence of gender on participants' responses to HC awareness. This yielded four leaves, known as decision rules, which for this example would be:

**Rule 1:** When  $(V3 \geq 0.5 = \text{Yes})$  AND  $(V4 \geq 0.5 = \text{Yes})$  THEN the Gender is Male

**Rule 2:** When  $(V3 \geq 0.5 = \text{Yes})$  AND  $(V4 < 0.5 = \text{No})$  THEN the Gender is Female

**Rule 3:** When ( $V3 < 0.5 = \text{No}$ ) AND ( $V4 \geq 0.5 = \text{Yes}$ ) THEN the Gender is Female

**Rule 4:** When ( $V3 < 0.5 = \text{No}$ ) AND ( $V4 < 0.5 = \text{No}$ ) THEN the Gender is Male

These rules are then given a percentage value, which represents the predominance of the influence that a factor, sub-factor, or categorical variable had in participants' responses. In this example, 2.7% of the influence for the third HC statement ("*Engineering education is harder, more time-consuming, and expensive because it has a direct impact on safety*") presented predominant influences from participants who self-identified as male. The percentage breakdown of these rules are included in the results section of the manuscript.

### Statistical Analysis

Informed upon the AML findings on the predominance of an influence of a given factor, sub-factor, or categorical variable, frequencies of responses were tabulated among the participants. These frequency counts were used to conduct a test of independence via chi-square analysis for the categories of race, gender, faculty rank, and institutional type.

Additionally, among the factors, association/correlation analysis was conducted on the R-squared values for each categorical response to find potential relationships. A best-fit line was run on each factor (e.g., HC awareness, emotions, self-efficacy, and self-advocacy) to see if there were positive or negative trends between each factor. Correlation coefficient values of 0.3 or less indicate weak correlations; values close to 0.5 indicated moderate relationships and above 0.7 indicate strong relationships. Positive or negative signs portrayed the directionality of the correlation [61].

#### 3.5.3. Qualitative Data Analysis: Qual

For the qualitative analysis of the survey, we used a method advanced by Lofland and colleagues [55] for social science framing. First, the researchers read through the written responses of all participants to understand the general tone of the responses. Next, each response was assessed line-by-line through open-coding [56] to identify themes and any possible question misunderstandings. Then, each written response was read a third time and focused-coding was conducted to identify distinct categories. These were then analyzed once more for interpretation, categorized into themes, connected theoretically, and the fit for each theme was assessed. For our analysis, added attention was paid to what could be identified or interpreted as an example of HC in from participants' personal narratives or additional experiences.

#### 3.6. Researchers' Positionality

Each researcher in this work comes from a different background and has developed an epistemology specific to the fields of engineering (faculty and postdoctoral fellow), curriculum and instruction (faculty), and social science (assistant administrator). These perspectives helps provide a holistic understanding of the HC explored for this population. Each researcher has been privy to the influences that HC could have in their professional formation, as well as has experienced both the negative and positive influences of such. It is the hope of the research team that, by uncovering this HC, power dynamics can become more democratized within this field [4].

## 4. Results

### 4.1. Quantitative Findings: QUAN

#### 4.1.1. Presence of HC Mechanisms among Engineering Faculty

To answer the first hypothesis (H1), a frequency count of faculty responses were measured for the four sub-factors (awareness, emotions, self-efficacy, and self-advocacy). For HC awareness, all faculty were approximately equal among what they considered was an HC in their field or not (Table 8). Among the statements identified as HC in engineering, were HC #1 ("*Senior faculty in engineering*

(e.g., tenured professor) deserve higher status, voice, and have more influence than engineering junior faculty”), HC #4 (“Not everyone can be an engineer”) and HC #6 (“Engineering instructors care more about the technical concepts and equations rather than the individual student’s success”). Among the statements that faculty regarded as not being hidden curriculum were HC #2 (“The ultimate goal of an engineering degree is to get a well-paying job”), HC #3 (“Engineering education is harder, more time-consuming, and expensive because it has a direct impact on safety”), and HC #5 (“To belong to the engineering community, your personality must fit in with everyone else’s (e.g., technically-driven, efficient, and assertive)”).

**Table 8.** Frequency counts of faculty participants’ agreement or disagreement that the statements were an HC in engineering.

Participant Response	HC #1	HC #2	HC #3	HC #4	HC #5	HC #6	SUMS
Yes. I agree this is HC	31	17	27	38	17	31	161
No. I disagree this is HC	22	36	26	16	37	22	159

A frequency count of the emotional valence (e.g., positive/negative) was tabulated for the participants as summarized in Table 9. While most faculty participants reported having to experience negative emotional valence to the HC statements, a combination of positive emotions or neither was also self-reported. Among the statements, HC #6 (“Engineering instructors care more about the technical concepts and equations rather than the individual student’s success”) yielded the most negative emotions while HC #3 (“Engineering education is harder, more time-consuming, and expensive because it has a direct impact on safety”) resulted in the most positive emotions.

**Table 9.** Frequency counts of faculty participants’ self-reported emotional valence response to the HC statements about engineering.

Emotional Valence	HC #1	HC #2	HC #3	HC #4	HC #5	HC #6	SUMS
Positive	5	12	18	10	7	7	59
Negative	31	25	15	20	32	33	156
Both	11	11	10	10	9	10	61
Neither	8	6	8	13	5	3	43

A frequency count of self-efficacy (e.g., confidence in the ability to succeed despite the HC) was tabulated for the participants as summarized in Table 10. Most engineering faculty participants reported feeling very confident about their success despite the possible presence of similar scenarios to the HC statements. Particularly, HC #4 (“Not everyone can be an engineer”) yielded the highest level of self-efficacy among participants. Among the lowest reported levels of self-efficacy, HC #1 (“Senior faculty in engineering (e.g., tenured professor) deserve higher status, voice, and have more influence than engineering junior faculty”) and HC #2 (“The ultimate goal of an engineering degree is to get a well-paying job”) were considered as having elements that would not enable them to succeed in these contexts.

**Table 10.** Frequency counts of faculty participants’ self-reported self-efficacy to the HC statements about engineering.

Self-Efficacy	HC #1	HC #2	HC #3	HC #4	HC #5	HC #6	SUMS
‘1’ (not at all confident)	7	7	5	4	6	6	35
‘2’ (mainly not confident)	10	5	7	10	8	7	47
‘3’ (somewhat confident)	16	15	12	12	13	13	81
‘4’ (moderately confident)	13	16	16	11	12	12	80
‘5’ (very confident)	9	12	15	18	16	17	87

A frequency count of self-advocacy (e.g., willingness to advocate for HC) was tabulated for the participants as summarized in Table 11. For the most part, engineering faculty were somewhat willing

to advocate for HC, particularly for HC #1 (“Senior faculty in engineering (e.g., tenured professor) deserve higher status, voice, and have more influence than engineering junior faculty”) and HC #4 (Not everyone can be an engineer”). Among the statements where the faculty were not at all willing to advocate was HC #3 (“Engineering education is harder, more time-consuming, and expensive because it has a direct impact on safety”) and HC #2 (“The ultimate goal of an engineering degree is to get a well-paying job”).

**Table 11.** Frequency counts of faculty participants’ self-reported self-efficacy to the HC statements about engineering.

Self-Advocacy	HC #1	HC #2	HC #3	HC #4	HC #5	HC #6	SUMS
‘1’ (not at all willing)	9	3	2	4	4	7	29
‘2’ (mainly not willing)	5	8	6	4	9	7	39
‘3’ (somewhat willing)	15	13	14	15	11	14	82
‘4’ (moderately willing)	12	15	15	13	13	14	82
‘5’ (very willing)	11	13	13	15	13	9	74

#### 4.1.2. Predominance of HC Factors, Sub-Factors, and Categorical Variables Based on AML and DT

To answer the second and third hypothesis (H2 and H3), the predominance of an influence among participant responses were calculated using AML and DT, through relative importance of variable algorithms [62–64]. A summary of the predominance of an influence (in the form of percentages) is presented in Table 12.

**Table 12.** Summary of the predominant influence (in the form of percentage) of the factors and sub-factors identified from the engineering faculty participant responses due to categorical variable.

Factor	Sub-Factor	Race	Gender	Faculty Rank	Institutional Type
Awareness	HC #1	33.5%	10.6%	26.8%	8.5%
	HC #2	26.5%	10.3%	3.1%	26.7%
	HC #3	9.5%	2.7%	53.7%	6.8%
	HC #4	7.1%	9.5%	1.6%	0.2%
	HC #5	1.1%	54.0%	1.0%	8.4%
	HC #6	22.3%	12.9%	13.8%	49.3%
Emotions	HC #1	75.0%	9.6%	13.0%	1.0%
	HC #2	7.9%	0.2%	19.3%	35.9%
	HC #3	3.0%	1.6%	9.8%	4.0%
	HC #4	6.2%	22.9%	1.6%	47.1%
	HC #5	1.7%	11.5%	2.3%	6.6%
	HC #6	6.2%	54.1%	54.1%	5.4%
Self-Efficacy	HC #1	11.4%	2.2%	1.4%	14.1%
	HC #2	9.1%	7.1%	44.3%	8.7%
	HC #3	42.3%	1.1%	37.1%	1.2%
	HC #4	33.6%	6.7%	1.5%	61.1%
	HC #5	1.4%	5.7%	5.5%	1.8%
	HC #6	2.2%	77.4%	10.2%	13.1%
Self-Advocacy	HC #1	12.8%	21.0%	11.7%	34.0%
	HC #2	11.2%	3.1%	4.9%	11.0%
	HC #3	12.5%	13.4%	13.9%	4.2%
	HC #4	49.8%	20.9%	17.3%	22.1%
	HC #5	12.0%	7.1%	49.2%	4.7%
	HC #6	1.7%	34.6%	3.1%	24.0%

The findings suggested that among the categorical variables, gender showed the highest influence among participant responses regardless of factor and sub-factor. For gender, the primary influences were found on HC #5 (“To belong to the engineering community, your personality must fit in with everyone else’s (e.g., technically-driven, efficient, and assertive)”) and HC #6 (“Engineering instructors care more about

*the technical concepts and equations rather than the individual student's success*"). We also found that for all engineering faculty, closely similar trends of predominance was found for HC awareness and emotion across the six statements. These latter trends did not parallel faculty responses to the self-efficacy and self-advocacy items.

Among the highest influences for race found was HC #5 ("To belong to the engineering community, your personality must fit in with everyone else's (e.g., technically-driven, efficient, and assertive)") followed by HC #3 ("Engineering education is harder, more time-consuming, and expensive because it has a direct impact on safety"). For faculty rank, the primary predominant influences were found for HC #6 followed by HC #3. For institutional type, main influences were found for HC #4 ("Not everyone can be an engineer") and HC #6.

From the AML findings, a chi-square analysis was conducted between the pairings of the four categorical variables (gender, race, institutional type, and faculty rank). Findings revealed that gender and institutional types showed the greatest relationships overall ( $\chi^2 = 18.422$ ;  $df = 8$ ;  $p < 0.05$ ). To further examine these two relationships and since Tier 1 had a higher percentage of respondents, these values were removed to identify the relationships of gender to the other institutional types. The same process was repeated for the other institutional types until a ranking in influence (denoted by  $p$ -values under 0.05) was measured. Findings confirmed the predominant influence of gender was found among the Tier 1 institutions (doctoral-granting institutions with large research programs) followed by close second (Tier 4; masters-granting institutions;  $p < 0.05$ ). Trailing behind were Tier 2, Tier 3, and Tier 5 institutions, respectively. For all other relationships (e.g., faculty rank versus institutional type; race versus institutional type; gender versus race; race versus faculty rank, etc.), no statistically significant relationships were found.

Among the factors, regression analysis was conducted between HC awareness and self-efficacy and HC awareness and emotions. Results were found to have a weak or moderate positive correlation ( $r = 0.28$  for self-efficacy;  $r = 0.42$  for emotions). HC awareness and self-advocacy revealed a weak negative correlation ( $r = -0.31$ ).

#### 4.2. Qualitative Findings: Qual

To answer the research question, a qualitative analysis of participants' written responses was conducted. These resulted in three recurrent themes: (a) professional expectations for engineering faculty; (b) sources of professional expectations; and (c) consequences of meeting professional expectations in engineering.

##### 4.2.1. Professional Expectations for Engineering Faculty

Findings suggested that teaching, service, and research were the top categories that respondents listed for what expectations they felt were placed on them as faculty. In addition, all faculty described expectations of time commitment and availability as being important. Among the responses, faculty described the expectation of being "able to work whenever needed (nights, weekends, holidays)" (Respondent 41, Full Professor, Tier 5, Male, Hispanic), or "to have all time outside of class to be free and uncommitted" (Respondent 12, Assistant Professor, Tier 5, Male, Hispanic) to be at odds with their work/life balance (i.e., "high productivity, no work-life balance" (Respondent 28, Lecturer, Tier 5, Male, White)).

Broader educational goals that faculty were expected to deliver included providing a high-quality engineering education, conferring credentials only to the deserving students, and meeting the Accreditation Board of Engineering and Technology (ABET) criteria [65]. More specific qualities that engineering faculty were expected to have included problem-solving, attention to detail, good communication skills, ability to work in a team, and being self-critical.

Being able to solve an equation is good, but what is more important is to be able to see if the answer is correct or not, like finding a negative resistance in a circuit problem can be mathematically correct but practically inconsistent with real circuit. Self-criticism should be taught more. This is what I try in my classes.

(Respondent 18, Lecturer, Tier 1, Male, White)

Two 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.

Other faculty elaborated that among professional expectations, there are elements of advocacy and allies that are needed, especially when considering the experiences of women and underrepresented groups in engineering:

I am a woman and an immigrant. I am a first generation student. I often have not seen students and colleagues respect me. After I stood up for myself things have started to change.

(Respondent 46, Associate Professor, Tier 1, Female, White)

Other important features are having the right networks/allies to get stuff done, as well as identifying allies of the majority group to speak up as well. When a woman stands up and talks about gender bias issues being a problem, it’s often not listened to as much as a man doing it.

(Respondent 48, Full Professor, Tier 1, Male, White)

#### 4.2.2. Sources of Professional Expectations

Survey respondents identified several origins to these professional expectations but most notably from students, peers, and themselves. Specifically, when describing faculties’ impression of student expectations, some respondents elaborated on their role in helping uncover HC in the classroom:

“I may be the only influence on this topic [hidden curriculum] the students are exposed to regularly”

(Respondent 34, Assistant Professor, Tier 5, Male, White)

Personally, I don’t think many of these . . . [HC statements] are truly hidden curriculum, at least in my classes I try to explain lessons whether they are part of mainstream engineering education or not.

(Respondent 28, Lecturer, Tier 5, Male, White)

Others, on the other hand, indicated that their intersectional identity and role could result in an opposite response from students in the classroom:

“ . . . as a faculty [ . . . ] students are less respectful of me due to my race/nationality/color of skin/religion..”

(Respondent 36, Assistant Professor, Tier 1, Female, Black)

“In an effort to be professional and polite there are times that I let it [students disrespecting me] slide and regret it later . . . ”

(Respondent 23, Associate Professor, Tier 1, Female, White)

Another theme that emerged was around how professional expectations from peers related to the intersectional identities of the faculty. One respondent said:

“As a woman in engineering, service is also expected of me more than my male colleagues. My female colleagues and I get asked constantly to do service, while our male colleagues are rarely asked (or, when they are on a committee, have no reservation about saying they are ‘too busy’ and ‘having the women to do work’)”

(Respondent 47, Assistant Professor, Tier 1, Female, Black)

Others faculty indicated that they too recognize their roles as being a source of encouragement and mentorship for underrepresented peers:

As I mentioned before, we are still doing things the way they were done 100 years ago. Maybe this is why our enrollment of women and minority groups continues to be so low. I made an effort to recruit minority and women faculty. I mentored them and was successful in helping them to earn tenure. In turn, they have attracted a more diverse group of students. So, I have seen how paying attention to diversity pays off!

(Respondent 32, Associate Professor, Tier 5, Male, White)

Keep on doing what you’re doing [referring to a main character in the video]! Although maybe do decrease your service level as an Asst. Prof. And go ahead and include questions on diverse engineers on the exam. It’s important.

(Respondent 49, Full Professor, Tier 1, Female, White)

#### 4.2.3. Consequences of Meeting Professional Expectations in Engineering

Several respondents expressed that some of the consequences they experienced while meeting professional expectations in engineering lied in trying to keep a work/life balance: “I could work 24/7 and still never be caught up” (Respondent 47, Assistant Professor, Tier 1, Female, Black); “there is never a break” (Respondent 44, Full Professor, Tier 1, Female, White); and “all areas of concern are unrealistic even for the most dedicated faculty” (Respondent 17, Assistant Professor, Tier 1, Female, White).

Thirty respondents stated that meeting the expectations of being a faculty member led to personal consequences, such as exhaustion and frustration. On the other hand, four faculty members elaborated that they do not feel meeting expectations should be exhausting because they love their jobs, suggesting that if faculty love their job they should not feel exhausted about meeting expectations. Among the participants that referenced reasons why meeting job expectations in engineering can be exhausting included confusion and pressures regarding grading, fulfilling administrative duties, responding to service requests and navigating an outdated system in engineering education. One respondent stated, “trying to be academically rigorous and supportive to the students and somehow getting research done at the same time is completely exhausting” (Respondent 23, Associate Professor, Tier 1, Female, White). Some respondents suggested that the exhaustion derives from their interactions with students who are underprepared and underperforming. One faculty wrote that “many students do not work hard enough” (Respondent 29, Assistant Professor, Tier 2, Female, White) and several faculty members elaborated on the academic rigor of the engineering curriculum. Three respondents referred to the competitive research environment coupled with the pressure to conduct innovative research.

Regarding the “frustrations” experienced by many engineering faculty participants, the challenges with navigating an outdated system in engineering education and the powerlessness that many feel for creating sustainable changes in engineering exist:

I am so completely frustrated with the older generation of professors. They’re mostly white, almost all male, and completely uninterested in how to teach better. They refuse to see student struggles as anything but laziness. I was first generation college student - I know what that’s like. I get good evaluations, I advise and mentor students, and I bend over backward to make sure their experience is good. But because it feels like I get no credit for it,

and previous attempts to advocate for change go nowhere, I don't feel like I can ever make a difference outside of the students I directly interact with.

(Respondent 25, Tier 1, Associate Professor, Female, White)

I can advocate for this in my classrooms, but not among the all-male, mostly white faculty.

(Respondent 47, Assistant Professor, Tier 1, Female, Black)

For others, these frustrations became their personal sources of motivation for changing the status quo in engineering:

It is difficult to do the right thing. The first step is rejecting the status quo. My anger and shame about the "good ole boys club" in engineering has helped me to fight against it!

(Respondent 32, Associate Professor, Tier 5, Male, White)

## 5. Discussion

### 5.1. QUAN Findings

In this study, it was found that engineering faculty were able to recognize the presence of hidden curriculum for some scenarios and not for others. For those statements that predominantly identified as HC, faculty recognized that the high demands for engineering (HC #3) and the professional demands of their field, may influence how engineering instructors are perceived regarding their care to students' success (HC #6). This parallels to what the engineering education literature states are the difficult nature of the field [44–50]. Additionally, regarding instructor care, it appears that there may be a level of awareness from the faculty that students may have a difficult time envisioning this care in engineering education [66].

We also found that HC awareness paralleled a lot of the emotional responses from participants and among the HC statements and as seen by the regression analysis results. It is possible that the design and presentation of the survey questions may have elicited unconscious or meta-conscious processes that influenced their awareness [24,25] to some of the HC statements or that it elicited indirect interpretations from the participants [23–25,57]. Further work is needed to understand these potential relationships better.

For self-efficacy, most faculties reported high levels of confidence in their ability to succeed despite statements like HC #4 (*"Not everyone can be an engineer"*) suggesting an individuals' internal motivations to persist and belong in such fields (Bonner et al., 2009). However, low levels of self-efficacy were reported for more systemic factors like HC #1 (*"Senior faculty in engineering (e.g., tenured professor) deserve higher status, voice, and have more influence than engineering junior faculty"*). This parallels to what the higher education literature states about the status and power faculty gain with the promotion and tenure process [38–40]. For self-advocacy, similar results were found compared to the self-efficacy results suggesting that these two factors may be related although additional participants and work would be needed to confirm these relationships in more detail.

In terms of prevalence, gender and institutional types appeared to have the greatest influences among research-intensive institution (Tier 1). It was interesting to find that among the prevalence of responses, Tier 1 (Ph.D. granting) and Tier 4 (M.S. granting) were more closely similar in influence compared to the other tiers. This is a unique finding and one that will warrant further exploration. It will be necessary to include higher representations of other institutions to identify if this trend still stands if other institutional types are represented in higher numbers.

One interesting observation was that neither faculty rank nor race appeared to result in differences among the faculty responses. For faculty rank, it appears that all faculty regardless of their role (e.g., lecturers, associate professors) are privy to the hidden curriculum of their fields in engineering and that these appear to not change regardless of the discipline of engineering that they may be teaching. Regarding race, it is still unclear if race did not play a role in faculty responses or if these

perspectives may have been muffled through the dominant perspectives from the White faculty in this study. Again, added participants to this study can help us clarify these in more detail.

Finally, the three hypotheses were partially confirmed in that all faculty were able to recognize some HC in their fields but our findings also suggested that identification of such were highly contextual (institutional type) and gendered but irrelevant to faculty rank (e.g., lecturers, associate professors). The literature points to the differential experiences that women and intersectional women have compared to their male counterparts [67,68] in engineering [59,69]. However, more studies are needed to understand the influences the formalization of institutional types had on the HC gained from these women faculty in engineering.

## 5.2. Qual Findings

From the qualitative findings and in response to RQ1, we were able to identify in more detail the lived realities of many of the engineering faculty who responded to this survey. In these, we also confirmed the predominant viewpoints of the inequalities existing for women and intersectional women in engineering in terms of fulfilling the professional expectations from students, peers, and themselves [59,67–69].

While there were many expectations expressed by the engineering faculty, many of them mirrored those found across institutions of higher education [38–40]. However, other field-specific nuances were identified. For example, many engineering faculties indicated attaining accreditation (e.g., ABET) was a characterizing factor of their success as educators. ABET is the leading accreditation that dictates the expectations of the education and training of engineering as is the main agency that faculty and administrators respond to in order to meet the increasing demands of the field [69]. Additionally, the need for rigor in the engineering education curriculum and the level of skill and preparedness of the student in the classroom was also referred to as important by the faculty. This finding parallels what engineering education researchers have referred to as the meritocratic nature of the discipline [44–50,69]. As Stevens and colleagues [69] have suggested, “one of the most significant implications of the meritocracy of difficulty in engineering is how it led engineering students to distinguish themselves from students in other majors and to place their discipline in a clearly superior position to others.” ([69], p. 1). It appears that some engineering faculty are mirroring this belief. Additional work is needed to explore this phenomenon further.

One encouraging finding was in the recognition from some faculty, across institutional types and faculty ranks, to advocate and encourage others for changing the status quo of engineering education. It appears that there is an overall sentiment that the system in engineering education has not changed in over a century (e.g., Respondent 32, Associate Professor, Tier 5, Male, White) and that personal and classroom changes through their roles as instructors (e.g., Respondent 34, Assistant Professor, Tier 5, Male, White) can help effect this change. Self-advocacy or a person’s willingness to take action and speak up about a matter to improve their quality of life [35] cannot occur without individuals having the motivation or desire to take control over their immediate situation or environment. It appears that for some engineering faculty, this sense of advocacy is becoming an integral component of their professional roles and responsibilities.

## 6. Limitations

This special issue study was conducted on 55 engineering faculty across different institutions of higher education but the perspectives of multiple faculties within the same institution were not explored. This would have allowed for a more granular study to explore potential similarities or differences between faculties within similar professional environments. Furthermore, more questions of the professionalization of engineering disciplines (e.g., mechanical engineering versus biological engineering) could have provided additional domain- and context-driven of the HC statements and perspectives analyzed in this work.

While it is not the belief that the findings are generalizable as HC is dependent on the individual, the situational, and the contextual [1–8], the findings of this work can help readers to understand how faculty are, or were, influenced by HC. Even though the results of this work may not represent the findings that were attained from the fully validated instrument, they represent the initial interpretations of faculty to our questions during the process of validation. Future studies will compare and contrast the findings from this study on engineering faculties and other participant groups (e.g., graduate students, undergraduate students, etc.) when data from the fully validated survey is analyzed [21].

Regardless, the findings from this special issue study can begin to shed light into the perspectives and mechanism by which engineering faculty understand HC, which may help scholars to see and understand the lived realities of many of these professionals.

## 7. Conclusions and Recommendations

The findings of this special issue study suggest a possible influence gender and institutional type in the beliefs, values, and attitudes that faculties carry about the HC in engineering. We also found that while some faculties are interested or are using their current roles to advocate on issues of engineering to their students and peers. However, some of the challenges for this action appear to relate to issues of gender and intersectionality, as well as race and institutional type.

From this work, the authors encourage the readers and, in particular, researchers and administrators, to conduct similar types of hidden curriculum studies internally at their institutions and colleges of engineering to explore the dynamics of the professional environments that different faculties are a part of. The authors call for a closer examination to the degree by which institutional resources are responding to the intersectional experiences of faculty (e.g., unequitable workloads for minoritized faculty). Finally, the authors encourage that for all faculty (tenure and non-tenure track), career trajectories and promotional paths become clearer to ensure transparency in evaluation processes.

## 8. Implications

This study has several implications. The first is that through a mixed-method, hidden curriculum approach, more awareness on the professional needs of each institutional type can be elevated. Second, the need for more individually- and culturally-responsive resources and interventions in engineering are presented. The findings of this special issue study purposed readers to reflect upon the connections that mechanisms such as emotions, self-efficacy, and self-advocacy can play in empowering and enabling all members of an academic engineering faculty group to participate in an equitable and safe environment. Finally, the techniques used in this work (i.e., decision tree) introduces a new way to handle complex datasets such as these and use them to more deeply inform the research and educational communities on the influences that professionalization of engineering faculty can have in their experiences at their colleges and institutions.

**Author Contributions:** Project Administration, Resources, Supervision, Conceptualization, Design, Methodology, Writing-Original Draft, Writing-Review and Editing: I.V.; Qualitative data analysis and Writing-Original Draft: T.C.; Qualitative Data Collection and Analysis and Writing-Review and Editing: M.D.S.; Quantitative Data Analysis and Writing-Review and Editing: M.T.H.K.

**Funding:** This material is based upon work supported by the National Science Foundation (NSF) No. EEC-1653140. Any opinions, findings, and conclusions or recommendations expressed in this material does not necessarily reflect those of NSF.

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

## References

1. Giroux, H.A. *Theory and Resistance in Education: Towards a Pedagogy for the Opposition*; Greenwood Publishing Group: Westport, CT, USA, 2001.
2. Kentli, F.D. Comparison of hidden curriculum theories. *Eur. J. Educ. Stud.* **2009**, *1*, 83–88.
3. Nieto, S. *Affirming Diversity: The Sociopolitical Context of Multicultural Education*; Longman: White Plains, NY, USA, 1992; ISBN 13 978-0131367340.
4. Villanueva, I.; Gelles, L.; Di Stefano, M.; Smith, B.; Tull, R.; Lord, S.; Benson, L.; Hunt, A.; Riley, D. What does hidden curriculum in engineering look like and how can it be explored? In Proceedings of the American Society of Engineering Education Annual Conference and Exposition, Minorities in Engineering Division, Salt Lake City, UT, USA, 24–27 June 2018; pp. 16.
5. Erickson, S.K. Engineering the Hidden Curriculum: How Women Doctoral Students in Engineering Navigate Belonging. Ph.D. Thesis, Arizona State University, Tempe, AZ, USA, 2007.
6. Tormey, R.; Le Duc, I.; Isaac, S.; Hardebolle, C.; Cardia, I. The formal and hidden curricula of ethics in engineering education. In Proceedings of the 43rd Annual SEFI Conference, Orléans, France, 29 June–2 July 2015.
7. Haeferty, F.W.; Gauferg, E.H. The hidden curriculum. In *A Practical Guide for Medical Teachers*, 5th ed.; Dent, J.A., Harden, R.M., Hunt, D., Eds.; Elsevier: Beijing, China, 2017; pp. 35–43.
8. Rabah, I. The influences of assessment in constructing a hidden curriculum in higher education: Can self and peer assessment bridge the gap between the formal and hidden curriculum? *Int. J. Hum. Soc. Sci.* **2012**, *2*, 236–242.
9. Borges, J.C.; Ferreira, T.C.; de Oliveira, M.S.B.; Macini, N.; Caldana, A.C.F. Hidden curriculum in student organizations: Learning, practice, socialization, and responsible management in a business school. *Int. J. Manag. Educ.* **2017**, *15*, 153–161. [[CrossRef](#)]
10. Baird, J.; Bracken, K.; Grierson, L.E. The relationship between perceived preceptor power use and student empowerment during clerkship rotations: A study of hidden curriculum. *Med. Educ.* **2016**, *50*, 778–785. [[CrossRef](#)] [[PubMed](#)]
11. Cotton, D.; Winter, J.; Bailey, I. Researching the hidden curriculum: Intentional and unintended messages. *J. Geogr. Higher Educ.* **2013**, *37*, 192–203. [[CrossRef](#)]
12. Joughin, G. The hidden curriculum revisited: A critical review of research into the influence of summative assessment on learning. *Assess. Eval. Higher Educ.* **2010**, *35*, 335–345. [[CrossRef](#)]
13. Margolis, E. *The Hidden Curriculum in Higher Education*; Routledge: New York, NY, USA, 2001; ISBN 0-415-92758-7.
14. Smith, B. *Mentoring at-Risk Students through the Hidden Curriculum of Higher Education*; Lexington, Books: Plymouth, UK, 2014; ISBN-13: 978-1498515801.
15. Lipsitt, D.R. Developmental life of the medical student: Curriculum considerations. *Acad. Psychiatry* **2015**, *39*, 63–69. [[CrossRef](#)] [[PubMed](#)]
16. Riva, S.; Monti, M.; Ianello, P.; Pravettoni, G.; Schulz, P.J.; Antonietti, A. A preliminary mixed-method investigation of trust and hidden signals in medical consultations. *PLoS ONE* **2014**, *9*, e90941. [[CrossRef](#)] [[PubMed](#)]
17. Street, R.L., Jr.; Gordon, H.; Haidet, P. Physicians' communication and perceptions of patients: Is it how they look, how they talk, or is it just the doctor? *Soc. Sci. Med.* **2007**, *65*, 586–598. [[CrossRef](#)] [[PubMed](#)]
18. Young, M.E.; Norman, G.R.; Humphreys, K.R. The role of medical language in changing public perceptions of illness. *PLoS ONE* **2008**, *3*, e3875. [[CrossRef](#)] [[PubMed](#)]
19. Mead, R.; Hejmadi, M.; Hurst, L.D. Teaching genetics prior to teaching evolution improves evolution understanding but not acceptance. *PLoS Biol.* **2017**, *15*, e2002255. [[CrossRef](#)] [[PubMed](#)]
20. Alsubaia, M.A. Hidden Curriculum as One of Current Issue of Curriculum. *J. Educ. Pract.* **2015**, *6*, 125–128.
21. Villanueva, I.; Di Stefano, M.; Gelles, L.; Youmans, K.; Hunt, A. Development and validation of a mixed-methods vignette survey to explore hidden curriculum in engineering. *JEE*, under review.
22. Hargreaves, A. *Teaching in the Knowledge Society: Education in the Age of Insecurity*; Teachers College Press: New York, NY, USA, 2003.
23. Winkielman, P.; Schooler, J.W. Splitting consciousness: Unconscious, conscious, and metaconscious processes in social cognition. *Eur. Rev. Soc. Psychol.* **2011**, *22*, 1–35. [[CrossRef](#)]

24. Winkielman, P.; Berridge, K.; Sher, S. Emotion, consciousness, and social behaviour. In *Handbook of Social Neuroscience*; Decety, J., Cacioppo, J.T., Eds.; Oxford University Press: Oxford, UK, 2011; pp. 195–211.
25. Zeeman, A. *Consciousness: A User's Guide*; Yale University Press: New Haven, CT, USA, 2002.
26. Koriat, A. *Metacognition and Consciousness*; Institute of Information Processing and Decision Making, University of Haifa: Haifa, Israel, 2006.
27. Schooler, J.W. Discovering memories in the light of meta-awareness. *J. Aggress. Maltreat. Trauma* **2001**, *4*, 105–136. [[CrossRef](#)]
28. Schooler, J.W. Re-representing consciousness: Dissociation between experience and meta-consciousness. *Trends Cogn. Sci.* **2002**, *6*, 339–344. [[CrossRef](#)]
29. Pekrun, R.; Linnenbrink-Garcia, L. Emotions in education: Conclusions and future directions. In *International Handbook of Emotions in Education*, 1st ed.; Pekrun, R., Linnenbrink-Garcia, L., Eds.; Taylor Francis: New York, NY, USA, 2014; pp. 659–675. ISBN 9780415895019.
30. Bandura, A. Perceived self-efficacy in cognitive development and functioning. *Educ. Psychol.* **1993**, *28*, 117–148. [[CrossRef](#)]
31. Bandura, A. *Self-Efficacy: The Exercise of Control*, 1st ed.; Worth Publishers: London, UK, 1997; SBN-13: 978-0716728504.
32. Caprara, G.V.; Di Giunta, L.; Eisenberg, N.; Gerbino, M.; Pastorelli, C.; Tramontano, C. Assessing Regulatory Emotional Self-Efficacy in Three Countries. *Psychol. Assess.* **2008**, *20*, 227–237. [[CrossRef](#)] [[PubMed](#)]
33. Sugarman, J.; Sokol, B. Human agency and development: An introduction and theoretical sketch. *New Ideas Psychol.* **2012**, *30*, 1–14. [[CrossRef](#)]
34. Schreiner, M. Effective self-advocacy: What students and special educators need to know. *Interv. Sch. Clin.* **2007**, *42*, 300–304. [[CrossRef](#)]
35. Ryan, T.G.; Griffiths, S. Self-advocacy and its impacts for adults with developmental disabilities. *Aust. J. Adult Learn.* **2015**, *55*, 31–55.
36. Ozolins, I.; Hall, H.; Peterson, R. The student voice: Recognising the hidden and informal curriculum in medicine. *Med. Teach.* **2008**, *30*, 606–611. [[CrossRef](#)] [[PubMed](#)]
37. Hundert, E.M.; Hafferty, F.; Christakis, D. Characteristics of the informal curriculum and trainee's ethical choices. *Acad. Med.* **1996**, *71*, 624–630. [[CrossRef](#)] [[PubMed](#)]
38. Gerber, J. Professionalization as the basis for academic freedom and faculty governance. *AAUP J. Acad. Freedom* **2010**, *1*, 1–26.
39. Abbott, A. *The System of Professions: An Essay on the Division of Expert Labor*; The University of Chicago Press: Chicago, IL, USA, 1988.
40. Wilensky, H.C. The professionalization for everyone. *Am. J. Sociol.* **1964**, *7*, 137–158. [[CrossRef](#)]
41. Larson, M.S. *The Rise of Professionalism: A Sociological Analysis*; University of California Press: Los Angeles, CA, USA, 2017.
42. Ross, D. *The Origins of American Social Science*; Cambridge University Press: New York, NY, USA, 1991.
43. Brubacher, J.S.; Rudy, W. *Higher Education in Transition*, 3rd ed.; Harper & Row: New York, NY, USA, 1976.
44. Villanueva, I.; Nadelson, L. Are we preparing our students to become engineers of the future or the past? *Int. J. Eng. Educ.* **2017**, *33*, 639–652.
45. Davis, M. Engineering as profession: Some methodological problems in its study. In *Engineering Identities, Epistemologies, and Values*, 1st ed.; Christensen, S.H., Didier, C., Jamison, A., Meganck, M., Mitcham, C., Newberry, B., Eds.; Springer: Cham, Switzerland, 2015; pp. 65–98. ISBN 978-3-319-16172-3.
46. Downey, G.L.; Lucena, J.C. Knowledge and professional identity in engineering: Code-switching and the metrics of progress. *Hist. Technol.* **2004**, *20*, 393–420. [[CrossRef](#)]
47. Baillie, C.; Pawley, A.L.; Riley, D. (Eds.) *Engineering and Social Justice*; Purdue University Press: West Lafayette, IN, USA, 2012.
48. Jolly, L.; Radcliffe, D. Reflexivity and hegemony: Changing engineers. In Proceedings of the 23th HERDSA Annual Conference, Toowoomba, Australia, 2–5 July 2000; pp. 357–365.
49. Riley, D. Engineering and social justice. In *Synthesis Lectures on Engineers, Technology, and Society*; Morgan and Claypool: San Rafael, CA, USA, 2008; Volume 3, pp. 1–152. [[CrossRef](#)]
50. Lohmann, J.R.; Froyd, J.E. Chronological and ontological development of engineering education as a field of scientific inquiry. In *Cambridge Handbook of Engineering Education Research*; Johri, A., Olds, B.M., Eds.; Cambridge University Press: Cambridge, MA, USA, 2010; pp. 1–25, ISBN-13: 978-1107014107.

51. Creswell, J.W. *Research Design*, 3rd ed.; Sage Publications, Inc.: Thousand Oak, CA, USA, 2008.
52. Creswell, J.W.; Plano Clark, V.L. *Designing and Conducting Mixed Methods Research*, 3rd ed.; Sage publications: Thousand Oaks, CA, USA, 2018.
53. Bryman, A. Integrating quantitative and qualitative research: How is it done? *Qual. Res.* **2006**, *6*, 97–113. [[CrossRef](#)]
54. Carnegie Classification of Institutions of Higher Education. 2018. Available online: [http://carnegieclassifications.iu.edu/classification\\_descriptions/basic.php](http://carnegieclassifications.iu.edu/classification_descriptions/basic.php) (accessed on 17 September 2018).
55. Loftland, J.; Snow, D.; Anderson, L.; Loftland, L.H. *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis*; Wadsworth, Cengage Learning: Belmont, CA, USA, 2006.
56. Saldaña, J. *The Coding Manual for Qualitative Researchers*, 3rd ed.; SAGE Publications: Los Angeles, CA, USA, 2016.
57. Horn, R.A. Developing a critical awareness of the hidden curriculum through media literacy. *JSTOR* **2003**, *76*, 298–300. [[CrossRef](#)]
58. Gilliam, F.D., Jr.; Bales, S.N. Strategic Framing Analysis: Reframing America's Youth. In *Social Policy Report, Giving Child and Youth Development Knowledge Away*; Society for Research in Child Development: Washington, DC, USA, 2001; Volume 15, Available online: <http://www.srcd.org/sites/default/files/documents/spr15-3.pdf> (accessed on 20 August 2018).
59. DeCuir-Gunby, J.T.; Long-Mitchell, L.A.; Grant, C. The emotionality of women professors of color in engineering: A critical race theory and critical race feminism perspective. In *Advances in Teacher Emotion Research*; Springer: Boston, MA, USA, 2009; pp. 323–342.
60. Alm, C.O.; Roth, D.; Sproat, R. Emotions from text: Machine learning for text-based emotion prediction. In Proceedings of the Conference on Human Language Technology and Empirical Methods in Natural Language Processing, Vancouver, BC, Canada, 6–8 October 2005; Association for Computational Linguistics: Stroudsburg, PA, USA, 2005; pp. 579–586.
61. Field, A. *Discovering Statistics Using IBM SPSS*, 4th ed.; SAGE: London, UK, 2013.
62. Song, Y.; Lu, Y. Decision tree methods: Applications for classification and prediction. *Shanghai Arch. Psychiatry* **2015**, *27*, 130–135. [[CrossRef](#)] [[PubMed](#)]
63. Khan, M.T.H.; Ahmed, F.; Kim, K.Y. Integration and visualization framework for data-driven resistance spot welded assembly design. In Proceedings of the 2017 13th IEEE Conference on Automation Science and Engineering (CASE), Xi'an, China, 20–23 August 2017.
64. Khan, M.T.H.; Demoly, F.; Kim, K.Y. Dynamic design intents capture with formal ontology and perdurants object concept for collaborative product design. In Proceedings of the Collaboration Technologies and Systems (CTS) International Conference, Orlando, FL, USA, 31 October–4 November 2016.
65. ABET Board of Directors. *Criteria for Accrediting Engineering Programs: Effective for Reviews during the 2018–2019 Accreditation Cycle*; Engineering Accreditation Commission: Baltimore, MD, USA, 2018; pp. 1–45.
66. Capobianco, B.M.; Yu, J.H. Using the construct of care to frame engineering as a caring profession toward promoting young girls' participation. *J. Women Minor. Sci. Eng.* **2014**, *20*, 21–33. [[CrossRef](#)]
67. Crenshaw, K. Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanf. Law Rev.* **1991**, 1241–1299. [[CrossRef](#)]
68. Davis, K. Intersectionality as buzzword: A sociology of science perspective on what makes a feminist theory successful. *Fem. Theory* **2008**, *9*, 67–85. [[CrossRef](#)]
69. Stevens, R.; Amos, D.M.; Garrison, L.; Jocuns, A. Engineering as lifestyle and a meritocracy of difficulty: Two pervasive beliefs among engineering student and their possible effects. In Proceedings of the American Society for Engineering Education Annual Conference, Honolulu, HI, USA, 24–27 June 2007; pp. 1–2.

