What Does Hidden Curriculum in Engineering Look Like and How Can It Be Explored?

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Work in Progress

Abstract

This work in progress paper describes the initial stages of a project which aims to characterize the mechanisms of hidden curriculum (HC) in engineering and identify methods for exploring this phenomenon. To effectively study the complex nature of HC, this work brings together researchers with a range of expertise (sociology, engineering education, engineering, statistics, policy analysis, curriculum and instruction) to develop a holistic approach to explore HC in engineering. This work describes the process of gathering input from this multidisciplinary team as well as the literature to develop a mixed-method instrument and model to explore the mechanisms behind HC in engineering, a new realm in engineering education. Early findings suggest that HC may require considerations of an individual's motivation, self-efficacy, and self-advocacy. The paper also discusses the initial stages of a vignette design used to elicit participants' responses and reactions to the presented scenes. The vignette scenes focus on HC elements present during classroom preparation and instruction in engineering. Preliminary work on these HC elements per scene are also discussed here.

Introduction

This work in progress paper summarizes the initial work on a National Science Foundation (NSF)-funded project (refer to the Acknowledgments section). One of the goals of this project was to explain the need for and rationale of the approaches that can more effectively help the engineering education research community to characterize the mechanisms behind hidden curriculum (HC) in engineering. Since HC has not been studied in engineering, there is a lack of well-established research methods and professional development interventions to study this complex phenomenon.

What is Hidden Curriculum?

In higher education, there is a need to understand the influences that school systems and curricula have on student outcomes. In the learning environment, curriculum can take one of three forms:

1. **Formal Curriculum:** Consist of a set of written requirements, rules, policies, and practices that serve as the official guidelines for engagement with individuals and evaluation of the quality of students' work [1]. Examples of these would be a course syllabus, a program of study, student-teacher contracts, and/or any documented and written course expectations.
2. **Null Curriculum:** Entails what is not taught in the classroom due to mandates from higher authorities, a teacher's lack of knowledge, or deeply ingrained assumptions and biases [1]. An example of this would be teachers and school systems choosing not to explain certain concepts (e.g., Christopher Columbus's colonization methods toward many native peoples when he "discovered" the Americas).
3. **Hidden Curriculum:** Represents the unwritten, unofficial, and often unintended lessons, values, and perspectives made by individuals and found in physical spaces within an academic

environment [1]-[3]. An example of HC would be how a teacher chooses to lecture in the front of the class as students quickly learn that the teacher is in control and is the sole *knowledge authority* and center of attention. Recognition of these messages would indicate that an individual has identified the HC of their classroom.

HC is an area that has been explored widely in fields such as education, psychology, business, and medicine [4]-[10] but has been relatively unaddressed in engineering [11]. Based on work from other disciplines [4]-[10], by identifying HC, particularly for underrepresented populations in engineering, knowledge and transfer of information are democratized and power dynamics can become more equitable. These "tacit messages to students about values, attitudes and principles" [2, p. 88] can guide the academic and career path for minorities in engineering and when revealed, can positively reinforce formal curricula through countervailing influences [7]. Neither the positive or negative implications nor the mechanisms behind HC in engineering have been explored.

The only study published explicitly alluding to the outcomes of HC in engineering was a sociological study of the experiences of women graduate students in engineering [11]. While important in uncovering the chilly climates for many women in engineering [11], the study did not point to any specific mechanisms nor did it include researchers from engineering or engineering education. Thus, this study seeks to develop a more holistic approach to explore HC in engineering by integrating the expertise of researchers in sociology, engineering education, engineering, statistics, policy analysis, and curriculum and instruction.

Goals and Research Questions

The goal of this work is to characterize HC in engineering and explore methods to study this phenomenon through engineering education research. Given the relatively unexplored elements of HC in engineering, the research questions for this work were:

1. What constructs should be considered to characterize HC in engineering?
2. What interventions, methods, and research approaches should be considered to characterize HC in engineering?

Method

The research team engaged in a series of yearlong discussions and preliminary work regarding considerations for studying and understanding HC in engineering. Capitalizing on the interdisciplinary expertise of the project team, which consists of consultants, advisory board members, and researchers on the grant, the methods employed were primarily a synthesis of the literature combined with semi-structured elicitation of the authors' professional and personal knowledge and experience related to different components of the project. After an extensive literature search of existing interventions and instruments, the following talking points were identified as the central piece of the discussions with the project team:

- **Potential characterization of mechanisms behind HC in engineering**
- **Initial thoughts for methods and instruments to characterize HC in engineering**

- **Preliminary considerations for appropriate interventions for HC in engineering**
- **Early identification of HC assumptions for engineering preparation and socialization**

The initial round of discussions occurred with two consultants. One consultant is an Interim Department Head and Associate Professor in Sociology and Criminal Justice with expertise in mentoring models for underrepresented groups and HC in higher education [6]. Another consultant is an Electrical Engineer, Engineering Education Researcher, and Associate Vice Provost for diversity with a specialization in professional development models for underrepresented groups [12], [13]. The discussions centered on preliminary discussions of all talking points described above.

Secondary discussions occurred with two advisory board members with expertise in Electrical Engineering and Biomedical Engineering, as well as microaggressions and stereotype threat in engineering [14], [15] and student motivation in engineering instruction and learning [16], respectively. The discussions centered on preliminary considerations of methods to characterize HC in engineering and early identification of HC assumptions for engineering preparation and exchange.

Tertiary discussions occurred with the senior personnel of the grant. The first individual specializes in analysis and mixed-methods research in education and community-based research projects [17]-[19]. These discussions were primarily on initial thoughts for methods and instruments to characterize HC in engineering and early identification for classroom preparation and delivery. The second individual is a senior policy analyst with a specialization in qualitative techniques and approaches for institutional change [20], [21]. The discussions primarily centered on appropriate interventions for HC in engineering. The third individual is a Chemical Engineer and Engineering Education Department Head and Researcher specializing in social justice and action research in engineering [22]. The discussions centered on characterization of mechanisms behind HC in engineering.

All discussions were collected as written documents, annotations, or memos from phone or face-to-face conversations. Collectively, the primary research team (principal investigator-Villanueva, graduate student-Gelles, and postdoctoral fellow-Di Stefano) discussed this collected data and conducted interpretive analysis of the comments. Themes acquired from the synthesized discussions were negotiated until 100% consensus was achieved. Subsequently, all pertinent methods, instruments, and interventions were created by the primary research team and are continued to be refined for future validation and reliability. Descriptions of these first stages will be discussed below.

Results

The synthesized literature review and findings from discussions with experts are structured around the four talking points presented below.

A. Potential characterization of mechanisms behind HC in engineering

The prevalence of either a negative or a positive HC can fundamentally operate through implicit mechanisms that are apparent to the individual (e.g., emotion, self-efficacy) but may not be to others. At the same time, these mechanisms (e.g., emotions and self-efficacy) may guide an individual's decision to take (or not take) action over their own motivation and trajectories (e.g., self-advocacy). Thus, there is a need *not just* to identify HC in engineering classrooms but also to characterize and track down those continual inward-to-outward transmissions of HC that may propel (or not propel) underrepresented groups to continue and persist in engineering.

a. Emotions:

In the classroom environment, relationships are integral to the learning and socialization process [23] of students and their instructors. These interpersonal interactions in the classroom are not devoid from *emotion*. Hargreaves posits that when a classroom environment becomes hyper-rational, data driven, and testing and tracking become target areas, factors such as "health, wellness, and physical activities are pushed to the sidelines" [24, p. 2] leading to stress, burn-out, and dropout. Fundamentally, individuals cannot evaluate an environment without feeling it first [25] as emotions serve to help an individual narrow down the other "infinite range of variables that underpin the choices we make" [24, p. 2]. Thus, emotional understanding may not be linear but does take place instantaneously and at a glance as expressions, gestures, visible signs of interest, concentration, frustration, disappointment, become evident to an individual in a classroom.

In higher education, the literature often describes a *rational* approach to engineering education that mostly excludes constructs of affect, emotions, and motivation [26], [27]. The prevalent HC in engineering assumes that emotion is not an important construct in the classroom and thus, factors such as well-being become pushed to the sidelines [24]. As emotions are beginning to be recognized in engineering education research, and their role on engineering student persistence and well-being [27]-[36], it will be important to understand HC in the context of emotion. Also, many educational psychologists argue that cognition and emotion are inextricably linked in educational settings [27]-[33] and as such, can inform how elements like performance can be mitigated or cultivated via HC in engineering.

b. Self-Efficacy:

In academic and other settings, an individual must possess *self-efficacy* (SE) [37], [38] or confidence in their ability to execute control over their own motivation, behavior, and social environment [37]. SE is an important regulatory tool for the management of challenges and setbacks [37], [38]. Prevailing negative forms of HC in engineering could serve to block mechanisms of self-efficacy in an individual and deter an individual from executing control over their engineering education experience.

c. Self-Advocacy:

Without self-efficacy, an individual may not have a desire or willingness to hear the voices previously not heard and speak up when advocating to improve their quality of life [39]. This aligns well with self-efficacy in that *self-advocacy* is premised on the notion that humans are agents of their actions [37]-[40]. Thus, as an individual learns about and uncovers HC in engineering, they must be empowered to have a desire to take action to self-advocate against the negative influences that HC may carry for engineering at their institution.

In many engineering classrooms, there is a stronger focus on passive learning (lectures) and reliance on epistemologies that focus on individual knowledge and competency [41]. As such, revealing HC through factors such as emotions, self-efficacy, and self-advocacy may be difficult. At the same time, by characterizing HC through these perpetuating components, a fundamental understanding of *how to identify HC* can surface. In other words, by using the same constructs that HC stands on, individuals can fundamentally reveal HC and determine how to act upon them. For this, HC assumptions implicitly stated in the engineering education literature can be used as the groundwork by which additional HC characterizations may be acknowledged. The next section expands upon this further.

B. Initial thoughts for methods and instruments to characterize HC in engineering

HC is traditionally studied qualitatively (e.g., ethnography) [42], [43] since it poses a powerful way to bring out the voices of the marginalized [44]. However, from a policy perspective, these voices are muffled, as they do not have the *power in numbers* effect that guides decisions and actions from important institutional players [45]. On the other hand, those methods that are quantitatively based [4]-[10], [46] rely on instruments that are tailored to a specific element of HC (e.g., training, assessment) and do not attempt to explore more holistically the mechanisms or situations where HC may manifest itself. For this reason, a mixed-method approach towards developing a HC in engineering instrument may be appropriate as the qualitative findings could be integrated with quantitative data [47]-[49] as a cohesive whole [50] to strengthen the findings of this phenomenon to key stakeholders [45], [50] and magnify the voices of the underrepresented.

In exploring HC in engineering, there has to be a recognition that this topic itself may not be noticeable by the participants, and/or that the experiences recollected by the participants may be too difficult to share. As such, the complexity and delicate nature of this topic may also warrant a different approach in the development of this mixed-method instrument. A vignette approach that embeds customizable prompts into a survey and that serves as a springboard to capture participants' perspectives and reactions shows promise. The authors believe that when individuals are positioned to experience scenarios, via vignettes, a frame of reference is created that will allow participants to first reflect upon and identify HC and then to respond and react to HC from an emotional, self-efficacy, and self-advocacy standpoint.

C. Preliminary considerations for appropriate interventions for HC in engineering

Recent literature has indicated that when engineering educators and students fail to recognize the persistence of a cultural influence in engineering education, undesirable consequences can result [51]. For example, a lack of culturally-responsive and holistic curricular content may limit students' understanding of their future professional roles [52], which may hinder students' sense of "ownership" (i.e., self-efficacy) of their professional actions and beliefs [53], [54]. In addition, a lack of social capital for underrepresented groups in engineering can lead to challenging university transitions [55], which may influence high attrition rates [56].

Few approaches to culturally-responsive interventions for engineering have been proposed. For example, the communities of practice (COP) intervention by Lave and Wenger [57] intends for groups of people with a common passion for doing and learning to have regular interactions. While there are advantages to COP, such as fluidity and leadership growth among its members, increasing tensions in the literature put into question the feasibility and durability of its interventions [58]. For example, weak continual one-on-one interactions between members, lack of identification with the community, and intangibility in developing and guiding administrative actions can limit the effectiveness of a COP intervention [58]. In the context of HC in engineering, these tensions may potentially ignite additional hidden messages about individuals' sense of belongingness to the group or their field of study.

Wilson-Lopez and colleagues [59] have presented assistive ways to help underrepresented populations, particularly Latinx (a gender-neutral term for Latino and Latina) engineering students, to integrate literacy and engineering instruction using writing interventions. While writing activities are important for cognitive and emotional regulation of tasks [59], it strongly relies on individual perceptions, with few opportunities for sharing and gaining alternative perspectives and a diversity of approaches to situational challenges. Also, in the context of HC in engineering, writing activities require an awareness of a problem. Since this phenomenon is not fully understood in engineering, it is very likely that engineering faculty and students are not yet able to recognize or understand the elements and potential influences of HC.

Interventions developed around HC should equip engineering faculty and students to first recognize HC, analyze the potential internal and external influences, and motivate them to identify appropriate self-advocacy approaches. Each step, in turn, should include intentionality for change and empowerment to the individual. While we are still in the process of identifying an appropriate intervention, based upon the work conducted by Smith [6], it is believed that a mentoring-based model, particularly around advocacy, could be an appropriate starting point. Smith's framework (mentoring levels for at-risk groups in higher education) focuses on three levels of mentoring. Each level focuses on the transmission of knowledge, information, and needed skills by key social players (e.g., professors, administrators) to decode HC to their mentees. The three levels of mentoring from Smith's framework [6] are:

(1) **Advising**: Low level of transmission of knowledge, information, and skills that decode the hidden curricula (e.g., talking about classes and career options).

(2) **Advocacy**: Medium level of transmission of knowledge, information, and skills that decode the hidden curricula (e.g., seeking out opportunities for students to work with faculty and staff).

(3) **Apprenticeship**: High level of transmission of knowledge, information, and skills that decode the hidden curricula (e.g., using role playing exercises to explain how to talk to a professor about receiving a low grade on an exam).

Smith argues that through an intentional and empowering relationship, individuals can be equipped to recognize HC at their institutions and that continued interactions may help support at-risk students to persist in their fields of study. The authors believe that the *advocacy* mentoring approach may be an appropriate level for many engineering faculty and students as it would push them to take ownership of their actions and move beyond traditional roles of advising. However, there may be some additional considerations (e.g., disciplines, majority and minority demographics) as this intervention model unfolds.

D. Early identification of HC assumptions for engineering preparation and socialization

Since little is known about HC in engineering, and whether the influences can be positive or negative [1]-[3], it is important to explore those contextual situations in the classroom that may be familiar to engineering students and faculty. For this, a systematic review of the literature was done to extract common phenomenon and stories of engineering norms and practices that influence underrepresented groups in engineering [60], [61]. These excerpts were then synthesized and categorized into engineering preparation and socialization. Select excerpts can be found in Table 1.

Table 1. Selected examples from engineering education journals and categorization examples

Selected Excerpts from Engineering Education Journals	Categorization of HC Scenario
"Professional dress was one area where women found they did not fit perceptions about engineering. Design class students were expected to wear professional dress when they met with clients and for formal presentations to faculty and other design teams. The sophomore class professor gave these instructions: "You should be at least as formal as the client. If he has a coat and tie, you keep your coat on. If he is in a shirt and tie, you can take off your jacket." This posed dilemmas for women that did not exist for men." [60, p. 163-164]	Engineering Socialization (gendered roles)
"On the surface, formal lines of communication, such as orientations, graduate advisors and handbooks purporting to facilitate women becoming graduate students are not always reliable. The alternative, which no one explicitly states, is to engage in the informal track through establishing social networks and building social capital." [61, p. 145]	Engineering Preparation (gendered roles and implicit/explicit communication)

The stories were synthesized into a video vignette that contained two sub-scenes that focused on engineering socialization and preparation. A video vignette was selected as its framing would enable participants to *see* and *feel* HC rather than read about it. Also, the vignette helps provide a more contextualized frame of reference by which participants can respond to a set of follow-up survey questions. Vignette surveys are traditionally used by sociologists to explore the attitudes, perceptions, beliefs, and norms [62] to hypothetical scenarios on "difficult topics of enquiry" among participants [63, p. 384] and is beginning to be used in engineering education research [60], [64]. In these vignettes, participants can respond to a familiar contextual situation usually by communicating their perceptions without necessarily asking them what they would personally do if placed in that situation [62]. In this way, participants are cued to HC examples that they can then reflect upon and extrapolate within their own disciplines and professions.

Villanueva wrote a draft vignette, in the form of a screenplay. This screenplay was shared with the project team and with several underrepresented engineering students, professional engineers, engineering educators/researchers, and media designers. A revised screenplay was shared with two professional screenwriters and then the hired actors for the video. A professional-grade video vignette with about 3.5 minutes per scene was created. In the first video scene, a White male engineering full professor (Dr. Brown) and a Latina engineering assistant professor (Dr. Garcia) are preparing for class in their respective offices and have a casual interaction in a university hallway before classes begin. In the second video scene, both instructors are teaching the same engineering course in two different course sections. The video indicates that the full professor is the lead instructor of this course and that the assistant professor is a new hire at that institution and supporting the lead instructor in this course. For each scene, participants were asked to identify the hidden messages they saw in the video. Preliminary findings from the first scene can be found in Table 2. The bold text portion in the participants' quotes in Table 2 highlights the connection between the participants' responses and the HC assumption statements developed as part of the analysis. These statements along with participants' open-ended responses to the instrument were used to inform future refinements of the instruments. Survey iteration, testing, analysis, and validation are continuing and will be published when finalized.

Table 2. Sample participant responses and HC statements identified in the first of the two video scenes.

Scene Description	Sample Participants Response to Scene	HC Statements Identified
Course Preparation and Discussion: A white male full professor in engineering and a Latina assistant professor in engineering prepare for the same undergraduate engineering course. Both co-teach the same course. The male professor is the lead instructor to the course and the assistant professor is a new faculty teaching the course.	1. **"Prioritize** which service activities are more important for her [Dr. Garcia], and dedicate amount of time that would not compromise other activities necessary for her tenure." (ID 6) 2. "You [Dr. Garcia] are a small cog in the system, that is ill posed, or it's getting highly competitive without real reward, **accept** it and continue suffering or change your profession!" (ID 17) 3. [To Dr. Brown] "Try to understand the background of other people, get out of your **comfort zone**." (ID 8) 4. [To Dr. Brown] "Need to **just ignore** those kinds of issues." (ID 18) 5. [To Dr. Brown] "I would not give him any advice. His **sense of entitlement** seems pretty high for me to deal with." (ID 20)	1. Work-life balance is needed for teaching, research, and service in academia and engineering 2. You are part of a system that is impossible to change in engineering 3. Need to get out of the comfort zone to address issues of equity and diversity in engineering 4. Just ignore the equity issue in engineering 5. White males who have successful careers in engineering feel entitled to impose their views of success on others

While still in the preliminary stages, the findings from Table 2 suggest the limitations for success among many underrepresented faculty populations in engineering. This mirrors what engineering educators state about the chilly climates of engineering [11], the normative and hegemonic environments of engineering [14], [15], and points to the need for participants to not just explicitly state the problem of HC but rather identify a strategy to advocate for action that will empower them to address this problem. The primary research team is currently exploring participants' recommendations for strategies around the HC to target future interventions and professional development tools.

Also, engineering students' responses to the vignettes as they compare and contrast to what faculty identified is being analyzed. One future component of this work is to consider the roles that institutional demographics (e.g., Hispanic Serving Institution versus a Predominantly White Institution), participants' cultures and backgrounds (e.g., gender, race, ethnicity), and engineering disciplines (e.g., Mechanical versus Chemical Engineering) play in the identification and strategies to mitigate the negative influences of HC in engineering.

Conclusion

In engineering, HC is not well understood, including its mechanisms or potential constructs. To our knowledge, there is no research that has attempted to explore the mechanisms and potential constructs behind HC in engineering. In this work, the authors have summarized some potential considerations and constructs that can be measured for the exploration of HC in engineering. Collectively, the considerations posit that HC identification is central and could be tied to an individual's emotions, self-efficacy, and self-advocacy. It is believed that when individuals experience scenarios, via vignettes, that center around HC in engineering, they can identify the HC through a frame of reference that can enable them to respond and react to the witnessed scenarios. To date, a video vignette with two scenes has been developed and embedded in a survey, which has begun to be tested with engineering faculty and students. After validation, it will be deployed to study HC in engineering across different participants, institutions, and engineering disciplines.

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