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How She Persisted: Working Women Engineers' Experiences in and Perceptions of Engineering

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ABSTRACT

Despite progress in engineering careers, gendered underrepresentation remains. Research on gender disparity suggests that women engineers have varied experiences both prior to and within their engineering careers, influencing their perceptions and persistence. The bulk of prior research has focused on women who lose interest prior to entering engineering fields. Yet, there is much to be learned from research on women who persisted; meaning they are currently working in the field as an engineer. This study recruited 46 women engineers from engineering firms and academic departments in the US and UK to participate in a survey querying sources of their engineering capital and habitus (per Bourdieu) and perceptions of engineering as a field. Participants reported academic resources (courses, internships, professors) and family as important. Women held positive perceptions of engineers and engineering, citing their use of non-cognitive skills (e.g., creativity, critical thinking) and improved social outcomes (e.g., betterment, impact) from engineering.

KEYWORDS

Bourdieu; capital; engineering; habitus, perceptions

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INTRODUCTION

The underrepresentation of women in such fields as science, technology, engineering, and math (STEM) has been researched since the 1970s and continues to be studied to this date. Society is missing the benefits of talented women contributing to these important career fields, and these competent and capable women are missing out on the professional leadership and high earning opportunities that STEM careers offer (Brandt, 2014). The field of engineering is considered one of the most unfriendly to women within all STEM fields (Hersh, 2000; Manoharan & Raghavan, 2019; Roberts & Ayre, 2002). While many research studies have focused on the barriers to women in STEM fields, particularly in engineering, few studies have focused on the factors for women's persistence. The field is grappling with questions around how and why women continue in the field; what dispositions and background experiences are at play? This focus uses the lens of Bourdieu's theory of habitus to analyze why some women persist. We examine the cultural capital and other background experiences that have gone into the taste, body language, knowledges, and embodiments of capital that make up habitus, and we use that to better understand why some women have persisted in and been successful in the field.

There is abundant research showing that women encounter barriers in the field. Multiple scholars using data from the U.S. have identified engineering as the most male-dominated profession at present (Fox, 2006; Hatmaker, 2013; Organisation for Economic Co-operation and Development [OECD], 2018). The shortage of women in engineering adversely affects a country's global competitiveness; it also fails to achieve the ethical goal of bridging gender equality in all walks of life (OECD, 2006, 2017, 2018). In the United States (U.S.), women received approximately 21.3% of bachelor's degrees in engineering (Yoder, 2018), comprising only 13-14% of the American engineering workforce (Society of Women Engineers, 2018; U.S. Bureau of Labor Statistics, 2017). Similarly, in the United Kingdom (U.K.), women make up 15.1% of all engineering undergraduates and 12.37% of the total engineering workforce, the lowest in Europe (Armitage et al., 2020; Atkins Limited, 2013; Women's Engineering Society [WES], 2021). Despite the multitude of studies which have explored and addressed the causes of this shortage or underrepresentation of women in engineering fields, progress for women in engineering is slow. In both the U.S. and the U.K., women are deeply underrepresented in engineering professions. In the U.S. context, engineering is viewed as a high-status, meritocratic career within a new culture of affluence and 'cool' (Cohen, 2014; Marks, 2014), yet this perception is belied by the underrepresentation of women in STEM fields (Barabas, 2015). Furthermore, engineering has recently become aligned with the misogyny promoted by a 'broculture' invading Silicon Valley and other engineering-focused geographical areas (Tam, 2018). The U.K. has a similar culture of engineering designed for a male audience (Powell, Bagilhole, Dainty, & Neale, 2004), and so both the U.S. and U.K. literature is used to explore the needs and gaps to warrant this study.

Women engineers have inherently different experiences than their male counterparts, both prior to *and* within engineering careers (Chu, 2005), both in the U.S. (National Science Foundation, 2019) and the U.K. (Engineering U.K., 2018; Pool, 2017). The bulk of the current research on this issue has focused on 'leaky' pipeline issues, namely, why undergraduate women choose not to enter (Sax et al., 2016) or fail to remain in engineering majors (Brandt, 2014). Research has also focused on women's attrition (Frehill, 2010) while in the field, focusing on how women become disenfranchised in engineering due to stereotype threat (Beasley & Fischer, 2012), gender bias (Morris, 2016), sex-based discrimination (Weber, 2018), and gendered stereotypes (Solnik, 2017), even for women in leadership positions (Ibironke, 2016). Women leave largely due to inequitable compensation, poor working conditions, and a lack of recognition and avenues for advancement (Fouad, Chang, Wan, & Singh, 2017). While there are many reasons women do not enter, or leave, the profession, Cardador and Hill (2018) argue that there is a dearth of research on the background and experiences of women who have *persisted* within the engineering profession; their "findings show gendered career paths in engineering firms and [findings] suggest that some career paths may put women (but not men) at greater risk of professional attrition" (p. 95). Persistence is defined in this paper as succeeding in obtaining an engineering degree and currently working as an engineer in the field. This raises the question, why are these women unique? Previous research suggests life experiences, coupled with their own perceptions of engineering, may provide them the impetus to navigate the organizational factors to persist in a male-dominated or masculine field (Fouad, Singh, Cappaert, Chang, & Wan, 2016). Theoretically, it may be due to their construction of a 'professional self' that fits within the culture of the engineering work that afforded them increased persistence as engineers. This is what makes current women engineers a group worthy of unique study, as persistence is a given, not a question, so we may reflect on the experiences that led them here.

Studies to date have been successful in describing problems within the engineer patriarchy such as historical and structural attributes that promote a wealthy, white, and male status quo (Frehill, 2004; Pawley, 2017, 2019; Secules & Turpen, 2017 as examples). However, this research focuses largely on women's experiences prior to and within the engineering workforce and not on the state of the workforce itself. Thus, this study presents perspectives from actively working women engineers who represent those few women who 'succeeded' by persisting in the engineering field. Our interest in sampled women from this population is to understand how they created their professional selves by drawing on their resources, capital, and habitus, to develop the resilience needed to persist in the male-dominated field of engineering. We use a Bourdieusian lens to examine this identity-making. While this study adds to the literature on the experiences of women in engineering by bringing to the fore a Bourdieusian lens combined with perceptions, this paper also extends other studies that have been done. For example, Beyer and Haller's (2006) scholarship focuses on gendered and inter-gendered differences that may be attributable to previous experience or social class. Cheryan, Ziegler, Montoya, and Jiang (2017) focused on the reasons that some STEM fields are more gender-balanced than others and argue that experiences in school—experiences that *we* would argue contribute to the building of their social and cultural capital—were shown to make a difference for some women in some professions.

The following section will introduce our theoretical and conceptual framework, based on a blend of the Bourdieusian concepts of habitus and capital, with the women's perception of their own experience as professional engineers and their perceptions of personality traits and dispositions that have helped them in the field. This section will be followed by a description of the methods deployed in the study, the findings of the study, and a discussion of implications based on the study.

THEORETICAL AND CONCEPTUAL FRAMEWORK

This study used a blend of theoretical perspectives to understand the dimensionality of the participants' experiences. Bourdieu's concept of habitus guided our assumptions about the ways that previous experiences and identity-making can create relationships to fields of study. Furthermore, Bourdieu's concepts of capital and habitus guided the questions we asked on the survey, as well as our interpretations of themes arising from data collection for analysis. Information was elicited from women's prior experiences and their present perceptions of engineers and engineering that have contributed to the 'construction' of their perseverance and evidenced persistence as part of a minority in the engineering workplace. Each part of our theoretical framework is defined and reviewed through the literature, identifying the specific strengths of each.

Bourdieu aims to explain class divisions and other divisions within society by focusing on the habits (of body and mind) that serve to demarcate people, and often get coopted in service of justifying oppressive divisions in society. While Bourdieu notes the impact of an unequal distribution of resources in society (Walther, 2014), he also notes that these divisions are often justified-based qualities that are seen as inherent (intelligence, taste, power) by that actually circulate through a complex relationship of embodiment to power. Bourdieu bases his theory on the metaphor of a game. The individuals, the players, have their own interests to pursuing the game, which focus on the realization of their personal desires. Individuals play in what is defined as a social space, divided into social structures or *fields*. Bourdieu (2000) uses the term fields to delineate different social situations, each one with different sets of rules. Individuals as the agents, bring to the fields their socially defined qualities and resources, which he defines as "capital" (Walther, 2014). Bourdieu defines capital as accumulated labor, experiences, or resources, or "the aggregate of the actual or potential resources which are linked to the possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition" (Bourdieu, 1986, p. 247). He recognizes three forms of capital (economic, social, and cultural), and states that the amount and composition of people's capital determine their position in the social space. Capital takes time to build, and it can change over time; however, people with a similar amount and composition of the different forms of capital are closer in social space and will occupy a similar social position (Pinxten & Lievens, 2014,). For the purpose of this study, capital is intended as the resources and acquired skills that women develop through their life experiences, such as the support of their family, their educational and professional experiences, their encounters with a mentor/role model, and the acquisition of knowledge through situated experiences like an internship. These forms of capital accrue over time to become a 'habitus' or way of living a life.

Along with the concepts of fields and capital, Bourdieu highlights the importance of the individual's habitus to position themselves in the world. In *Outline of a Theory of Practice*, Bourdieu (1977) articulated the idea of habitus as a way of being, their dispositions and acquired behaviours, which derive from their life conditionings. As Reay claims, "Bourdieu developed the concept of habitus to demonstrate the ways in which not only is the body in the social world, but also the ways in which the social world is in the body" (Bourdieu, 1977 in Reay, 2004, p. 432). Bourdieu's definition sees habitus as:

> a socialised body. A structured body, a body which has incorporated the immanent structures of a world or of a particular sector of that world - a field - and which structures the perception of that world as well as action in that world. (Bourdieu, 1998a, in Reay, 2004, p. 432).

Bourdieu (1990) refined his habitus thinking as one's "dispositions durably inculcated by the possibilities and impossibilities, freedoms and necessities, opportunities and prohibitions inscribed in the objective conditions" (p. 54), conveying the idea of a sense of habitus, borne of practicality and early experiences, how one is (or is not) able to generate what he again termed, a "feel for the game" (p. 66).

Habitus, for Bourdieu, is a way of describing the durable and long-lasting dispositions the individual possesses, such as "the way society becomes deposited in persons in the form of lasting dispositions, or trained capacities and structured propensities to think, feel and act in determinant ways, which then guide them" (Wacquant, 2005, as cited in Navarro, 2006, p. 16). Habitus is the taken-for-granted manner of living specific to every individual, rooted in the family upbringing, but also rooted in experiences of social class, gender, and other positionalities. Per Gilbert, Farrand, and Lankshear (2013, p. 349), "for Bourdieu, individuals with the closest alignment of field and habitus experience doxa or a 'feel for the game.' A reflexive quality…enabling individuals to operate effectively," suggesting there are elements of typologies or personalities that embody the social system and perceptions thereof. Pickel (2005) has described phenomena that perceptions of personality (i.e., individual forms of behaving, thinking, feeling, etc.) provide unique insights to a habitus system (i.e., patterns of behaving, thinking, feeling, etc.). Pickel codified this relationship as the 'habitus-personality complex' and established a model so we may utilize that relationship to explore how individuals' perceptions of personality can provide insight to the habitus of the same domain (such as engineering).

The relationship between a social field (in this case, the engineering industry) and habitus produces a Bourdieusian *bodily hexis*, transmitted through one's body and subconsciously through one's dispositions (Webb, Schirato, & Danaher, 2002) meaning that habitus is both subconscious and embedded bodily. Thus, the bodily hexis is the historical summation of one's experiences, which mediates current behavioral actions and intentions. Therefore, habitus has an indelible impact on people's lives and opportunities, bringing benefits, support, connections, or on the contrary, tensions, struggles, obstacles. Bourdieu sees habitus as an open possibility, for either reproducing the social structure in place of inequality (Huppatz, 2012), or for bringing the possibility of transformation, enabling the individual to become conscious of the need for a change (Reay, 2004). In the context of the current study, the concept of habitus is strictly related to the development of a professional 'self' or identity in the workplace. As women develop, shape, negotiate, and renegotiate their identity as women engineers in a male-centric environment, they are "durably inculcated by the possibilities and impossibilities…opportunities and prohibition inscribed in the objective conditions" of the field (Bourdieu, 1990 as cited in Reay, 2004, p. 433).] As Bourdieu points out, we generally think of the 'body' as a product of the 'self,' of one's consciousness. However, Bourdieu emphasizes the 'individual, self-contained body' is a product of habitus: the body and the way we personified our habitus can, on the contrary, shape our thinking, our beliefs, our identity (Webb et al., 2002, p.38), and for this study, this includes perceptions.

Multiple scholars have used the concept of habitus to describe why it might be that women and girls find themselves out of step with STEM—and particularly engineering—fields of practice. For example, Bonaldi and Silva (2014) conducted a study on the importance of understanding habitus and cultural capital for women as undergraduates in engineering. Their research suggested that when women were able to learn and deploy certain practices of cultural capital, they were able to acquire some form of habitus—or ways of being—that allowed them to see themselves as part of the engineering field. Steuer, Berg, and Leicht-Scholten (2015) researched habitus as a series of habits of behavior and habits of mind for women in engineering in higher education. Edgerton, Peter, and Roberts (2014) focused on habitus and cultural capital for secondary students and their persistence into higher education, the workforce, and into graduate work. Mlambo and Mabokela (2017) studied women engineer academics and their articulation of why and how they persisted into academia; often forms of habitus determined persistence or lack thereof. In reference to engineering, this can include what Hunt (2016, p. 23) has indicated, that "a lack of mentoring and networks…are the more promising of the existing explanations for excess female exits" from engineering.

Habitus guides our understanding of the ways that the participants in this study use their knowledge and resources to cope with their mismatch with the white male-dominated norms of the field. Previous studies have also shown that women leverage their background experiences and resources in order to cope with feelings of mismatch or oppression (Wilkins-Yel, Simpson, & Sparks, 2019). These coping strategies (including the ways that you speak, carry yourself, and other embodied parts) form what Bourdieu (1977) would characterize as habitus. While habitus is an oft-used way of analyzing women (or the lack thereof) in engineering in primary through tertiary contexts, and even in the STEM workforce, less work has been done on the habitus that women engineers have cultivated as part of their identity-making processes that have led them to *become* engineers. This study adds to knowledge in this area by analyzing the ways that the study participants talked about habits and ways of being that they had to adapt to *become* an engineer.

Habitus is intimately entwined with sustained interest (persistence) in the engineering workplace, as well as class-based knowledge that may help some women persist in engineering. Considering how asymmetrical the engineering field is in gender, there is an ongoing challenge for researchers to understand how ‘engineering habitus’ may be changing, influencing women to not only pursue but also persist in an engineering career (Bonaldi & Silva, 2014). Factors such as class and ethnicity are intrinsically related and thusly embedded in the concepts of habitus and capital. Per Turnbull, Locke, Vanholsbeeck and O’Neale (2019, p. 6), “as the representation of the social world also influences the formation of habitus, the world and habitus share a reciprocal relationship. This relationship facilitates the cultural reproduction of inequity over time.” The authors found this attribute of habitus and capital significant in understanding why sampled undergraduate women struggled to find a belonging in university-level physics courses. Working-class women struggle to remain in male-dominated fields like engineering (Torre, 2017). Women often experience their own embodied cultural knowledge as a mismatch with that of the male-dominated space. This is even more true for women of color, who find their capital and embodied habitus out of alignment with the male dominated, and invariably white, norms of the field (Samuelson & Litzler, 2016).

In this research study, we parse the differences between Bourdieu’s concepts of capital and habitus, in agreement with Edgerton and Roberts (2014), who argued that capital and habitus are related, yet different, constructs. Therefore, it is important that we too differentiate these constructs as a means of exploring what experiences and connections (capital), as well as what communities, context, and dispositions (habitus) potentially influenced women engineers’ persistence in engineering. Because of the importance that has been placed on capital and habitus in contributing to women’s self-efficacy and confidence *for* engineering disciplines (Falk, Rottinghaus, Casanova, Borgen, & Betz, 2017; Marra, Rodgers, Shen, & Bogue, 2009; Pool, 2017; Wilson, Bates, Scott, Painter, & Schaffer, 2015), it bears further examination of the role of capital and habitus among women actively engaged *in* engineering careers.

Perception is the secondary frame for this study, as it mediates women’s career aspirations and the roles they take on within society (Frome, Alfed, Eccles, & Barber, 2006). Specifically, gender expectations and stereotype threats have been evidenced to play a major role for women students in career aspirations (Deemer, Thoman, Chase, & Smith, 2014), especially for women students entering engineering (Cadaret, Hartung, Subich, & Weigold, 2017). Perceptions are connected to habitus, and yet they are also different constructs that contribute to a woman’s experience in the field. As women form negative perceptions of the field through negative experiences, they find themselves *interested* in STEM yet have no intention of *pursuing* a career in STEM (Kitts, 2009). When programs intentionally seek to dispel stereotypes about women in engineering, women are much more attracted to the discipline (Wells, Jones & Davidson, 2019). Thus, perceptions are significant as they are influenced by one's capital and habitus (Davey, 2009), suggesting the perceptions (of engineering) one possesses can give insight to one's capital and habitus (for engineering). This perception of engineering continues to be skewed among both male and female students, with women students experiencing wider misperceptions of engineering than male students (Drew, 2011; Johnson & Miller, 2002; Masnick, Valenti, Cox, & Osman, 2010). Furthermore, Kelley and Bryan (2018) found that "women consider the typical engineer to be more masculine compared to the impressions gathered from men" (p.22). As the women in our study reported disparate perceptions of engineers and engineering, this may provide insight to how they have constructed their persistent 'professional selves' through their engineering-based experiences (capital and habitus).

This research explores paths of women in engineering through a novel conceptual framework, blending past with present, through a Bourdieusian perspective. We assume no explicit relationships or directionality between these concepts within the conceptual frame, rather we look to leverage their strengths to provide deeper insight to the various ways sampled women's past experiences and present perceptions holistically contribute to their evidenced persistence in the engineering field. We are permitted to assume this because of the reciprocal nature between capital and habitus (i.e., the process by which capital becomes embodied over time both physically and mentally). As such, the research questions were as follows: What experiences and persons do these women report as developing their capital and habitus in or for engineering? What are participants' perceptions of engineering and engineering careers?

Methods

This research sought to invite actively working women engineers in large, mid-size, and small engineering firms with a presence in the U.S. and U.K. to participate in a survey on experiences and people that cultivated their understandings of engineering as a field, as well as their present perceptions of engineers and engineering. The online (Qualtrics) survey was sent to the Human Resources departments of four major women-focused engineering professional organizations as well as 50 major and minor (randomly selected) engineering firms in the U.S. and the U.K. Direct links were posted to relevant areas of social media (i.e. Facebook, Twitter, and Reddit) women engineers may be likely to visit, view and potentially access the survey for 10 months in 2018. This data is from a larger study on women engineers that explores their relationships to engineers and engineering to understand their persistence.

Participants

Forty-six women who identified as female engineers provided their informed consent and responded to parts of the survey from the 54 women that had begun the survey (a response rate of 85%). Most respondents (*n* = 31, 67%) were under the age of 40 and mainly (*n* = 43, 93%) from the U.S. Among the U.S. respondents, 19 different states were represented with the most subjects identifying their engineering employment in Florida (*n* = 5), Colorado (*n* = 5), and Texas (*n* = 4). Respondents' average engineering career was 10 years (*SD* = 11 years) mainly in the main fields of mechanical (n = 13), electrical (n = 11), chemical (n = 7), civil (n = 7) engineering, mainly working at large (n = 14, 37%) for-profit engineering firms or academia (n = 9, 24%). Participants were not required to answer any specific or all questions, and sections were randomized to ensure coverage, therefore, sample sizes are reported by item in the subsequent tables in the results section.

As multiple scholars have mentioned, using online recruiting methods, even when a large pool of potential respondents is available, can yield a high level of non-response (Topolovec-Vranic, & Natarajan, 2016; Sax, Gilmartin, & Bryant, 2003). Nevertheless, as Boddy (2016) argued, surveys that integrate deep questioning techniques—including open answers, visual field development, and other techniques—do not require a large participant size to yield valuable results. Additionally, Tran, Porcher, Falissard, and Ravaud (2016) argued that, while it is good practice to get an average of ~150 participants for a closed-question study, their analysis showed that significant differences in collection of new themes occurred when 30 participants had completed the study. In this current study, participants were asked closed- and open-ended questions.

Instrument

An online survey leveraged Likert-style and open-ended questions to collect data and create an understanding of what habitus and capital-based aspects contributed to their professional selves and perceptions of their field. This variety of instrumentation permitted the conceptual and holistic analysis of experience to address the research questions of interest.

To explore the role of capital and habitus in the construction of a 'professional self,' women were asked to rank how individuals (e.g., primary and secondary teachers, professors, mentors, parent/s, sibling/s, community members) and engineering-specific experiences (after-school engineering programs, engineering classes in secondary school or university, internships) were influential to their choice in pursuing and remaining in engineering careers. Respondents could indicate positive experiences (i.e., very much or somewhat inspired me to become an engineer) or negative experiences (i.e., did not inspire me to become an engineer). If those individuals or experiences were not available, they were able to select a neutral or 'not applicable' response. This is important because a lack of access to these types of experiences is just as important to a finding as positive or negative experiences. This would corroborate previous literature showing that women often lack the same types of experiences that allow them to experience 'fit' in this field. For analysis, rankings are reported in aggregate to suggest trends in responses between positive and negative/neutral experiences. Since respondents did not have to enter a response for each category, there are varying N-sizes in each category; notably over half of the total respondents participated in one or the other of these two sections of the survey (N > 27). Items banks were randomized in their presentation and given there was no discernable pattern that suggested one bank of questions were favored over the other, attrition may be attributed to survey fatigue. It should be noted that we are not restricting capital and habitus to just these responses, but rather leveraging these responses to garner insight to their professional selves and how it connects with their perceptions.

To explore women engineers' perceptions of engineers and engineering, they were asked to write three words that came to their minds when thinking about *engineers* and *engineering*. Ninety words were captured from 30 respondents and were consolidated into themes for first pass coding, then, using an open coding schema, themes were developed based upon the participant responses. Furthermore, the Bourdieusian lens was used to develop themes from these responses. Words associated with themes (descriptors) were aggregated and quantified for descriptive reporting. Theme development and thematic analysis processes were conducted according to steps as outlined in the literature (Fereday & Muir-Cochrane, 2006; Gavin, 2008; Vaismoradi, Jones, Turunen, & Snelgrove, 2016). For trustworthiness and transparency, the full data set can be found in Appendix A and B, respectively.

Results

To examine the role of engineering capital and habitus in research question 1, sampled women categorized how influential capital-contributing experiences and significant habitus-contributing individuals were in their choice to follow and persist in engineering careers. Possible responses were partitioned between *positive* (very much or somewhat inspired me to become an engineer) and *negative/neutral* (did not inspire me or not applicable) to visualize how each experience or persons contributed respectively to sampled women's sources of capital and habitus. Table 1 shows the rankings for experiences (capital) and Table 2 shows the ranking of individuals (habitus) through frequency counts for each category.

Table 1: Experiences that Positively or Negatively/Neutrally Influenced Pursuit of Engineering

Capital Experiences	**Frequency Count of Responses**			
	Positive		***Negative/Neutral***	
	Very much inspired me to become an engineer	Somewhat inspired me to become an engineer	Did not inspire me to become an engineer	Not applicable
Engineering classes at College or University (*n*=27)	11 (41%)	13 (48%)	2 (7%)	1 (4%)
Engineering Internship (*n* =28)	11 (39%)	7 (25%)	4 (14%)	6 (22%)
Science and/or Engineering Out of School Programs (*n* =26)	7 (27%)	3 (11.5%)	3 (11.5%)	13 (50%)
Engineering classes in Secondary Education (Middle and/or High School) (*n* =27)	3 (11%)	6 (22%)	5 (19%)	13 (48%)

Note: Respondents were not required to enter a response for each capital experience category, therefore there are varying n-sizes listed.
The selected response, "Not Applicable" was an answer choice for participants.

While the table above shows the responses of women who experienced both positive and negative experiences, the fact that some women articulated the fact that they did not have these experiences is also telling. These women did not have the chance to accrue experiences that they might have relied on as coping resources. For capital building experiences, women reported participation in science and/or engineering out of school (including summer or after-school experiences) favorably (n = 10) more than negatively or neutrally (n = 3). Similar findings were found for at school engineering programs (positive responses (n = 9), negative/neutral (n = 5)); yet more women reported they did not have such experiences (n = 13) either in or out of school respectively. The most positive experiences included engineering classes at university (N = 24) and internships (n = 18). Some women reported not having access to engineering classes (n = 1) or internship (n = 6) experiences.

Table 2: Individuals who Positively or Negatively/Neutrally Influenced Pursuit of Engineering

Habitus Fostering Individuals	**Frequency Count of Responses**			
	Positive		***Negative/Neutral***	
	Very much inspired me to become an engineer	Somewhat inspired me to become an engineer	Did not inspire me to become an engineer	Not Applicable or Available
Teachers, Professors (*n* = 68)	**21**	**24**	**14**	**9**
In Primary (Elementary, Middle Grades)	1	4	16	4
In Secondary (High School)	7	11	6	2
In College or at University	13	9	2	3
Mentors (*n* = 54)	**9**	**15**	**8**	**22**
Same Sex (Female)	5	5	5	13
Different Sex (Male)	4	10	3	9
Family Members (*n* = 57)	**21**	**16**	**15**	**5**
Parents	13	9	5	2
Extended Family (Siblings, etc.)	8	7	10	3
Non-Family Members (*n* = 28) (Members of their Community)	**4**	**7**	**10**	**7**

Note: Respondents not required to enter a response for each habitus fostering individual category, therefore there are varying n-sizes listed.
Bold categories are the sum of responses in subcategories.

Respondents reported that teachers and professors were positive influences on their choices to become and remain as an engineer (n = 45 positive, n = 23 negative), especially secondary teachers (n = 18) and professors (n = 22). Primary teachers were largely reported as not inspiring (*n* = 16) in becoming an engineer. Mentors were reported as having both positive (*n* = 24) and negative or neutral (*n* = 8) roles, if they were available at all (*n* = 22). The positive influence due to the sex of the mentor was negligible (female, *n* = 10 and male, *n* = 14). Although respondents reported female mentors were not as inspiring as male mentors (*n* = 5 compared to (*n* = 3), overwhelmingly women reported not having access to any mentor (*n* = 22); and fewer female mentors (*n* = 13) than male mentors (*n* = 9). Family members played the second-largest role related to inspiration for a career in engineering (*n* = 37), as well as not being inspiring, (*n* = 20). Parents were reported most positively (*n* = 22), and extended family most negatively/neutrally (*n* = 13). Members of their community (with no familial relationship) were reported to be less inspirational to sampled women (*n* = 17) than inspiring (*n* = 11) and were reported to have very little effect on their interest in engineering.

To explore research question 2, respondents were asked to provide up to three words to describe their thoughts on engineering and engineers, respectively. Among the 46 respondents, 90 words were entered for each term and counted (frequency) from the whole (percentage). Words associated with themes (descriptors) were combined and counted; the results of this coding process are found in Table 3 for engineer, and Table 4 for engineering.

Table 3: What Three Words Come to Your Mind When You Think of an Engineer? (*N* = 30, 90 total responses)

Theme	**Descriptors**	***f***	**%**
An Engineer is (a)…	Problem-solver, solver, builder, optimizer, change-maker, thinker, creator, designer, inventor, scientific, highly educated	**15**	**16.7%**
Engineers' Personality		**57**	**63.3%**
Positive Traits	smart, intelligent, dedicated, dependable, understanding, knowledgeable, sensible, collaborative, trustworthy, insight[ful], quick,persistent, clever, confident, logical, creative, skilled, progressive, organized, endeavor, efficient, hard-worker	*42*	*46.6%*
Neutral Traits	reserved, calculated, analytical, quiet, meticulous, driven, practical, technical	*11*	*12.2%*
Negative Traits	stuffy, pretentious, exhausted, addicted	*4*	*4.0%*
Engineer's Function	solution, design, improve	**3**	**3.3%**
Societal Recognition	good position, respect, pride	**3**	**3.3%**
Tools of an Engineer	hard hat, drawings, calculator, glasses, oscilloscope, computer, Math, degree	**8**	**8.9%**
Engineer's Gender	male, man	**2**	**2.2%**
Individual's Identity	person, me	**2**	**2.2%**

N = 30 from 90 total responses

Respondents reported positive personality traits for engineers (*n* = 42, 46.6%), more than negative and neutral traits combined (*n* = 15, 16.7%).Fifteen responses (16.7%) described the attributes of an engineer; more specifically how being an engineer was associated with the tools they used (*n* = 8, 8.9%), their function (*n* = 3, 3.3%) and the recognition they receive from society (*n* = 3, 3.3%), and to a lesser extent, their individual identity (*n* = 2, 2.2%) and typical gender (*n* = 2, 2.2%).

Whereas for engineering, respondents reported the characteristics (*n* = 30, 33.3%) skills and tools (*n* = 30, 33.3%), and other aspects (*n* = 30, 33.3%) of the engineering occupation equally. Skills (*n* = 14, 15.6%) and tools (*n* = 16, 17.8%) were further parsed into subcategories. Skills included individual (*n* = 7, 7.8%), team (*n* = 5, 5.6%), and mindset (*n* = 2, 2.2%), whereas tools included materials, (*n* = 5, 5.6%), technology (*n* = 5, 5.6%), and processes (*n* = 6, 6.7%). Words related to engineering outcomes included engineering outcomes on society (*n* = 22, 24.4%) as well as benefits (*n* = 3, 3.3%) and challenges (*n* = 5, 5.6%) within engineering.

Table 4: What Three Words Come to Your Mind When You Think of Engineering?

Theme	Descriptors	*f*	%
Characteristics of Engineering	Problem-solving, creativity, industry, iteration, science, function, precision, usability, open-ended, critical thinking, searching, analytical, technical, innovation, application, linkages, implementation	**30**	**33.3%**
Skills Needed		**14**	**15.6%**
Individual Skills	steady, focused, independent, work, intelligence, diligent, discipline	*7*	*7.8%*
Team Skills	team, communication, coordination, discipline, collaboration, efficiency	*5*	*5.6%*
Mindset	pragmatism, skepticism	*2*	*2.2%*
Tools Needed		**16**	**17.8%**
Materials	asphalt, sewer, electricity, gears, optics	*5*	*5.6%*
Technology	automation, *AutoCAD*, dimension, device, technology	*5*	*5.6%*
Processes	math, algorithms	*6*	*6.7%*
Engineering Occupation		**30**	**33.3%**
Outcomes	betterment, advancing, fixing, design, solution, building, impact, structures, function, improvement	22	24.4%
Benefits	fun, exciting, diverse	3	3.3%
Challenges	challenge, difficult, complex, differences	5	5.6%

N = 30 from 90 total responses

Discussion

There were many experiences that participants in this study found inspiring, and that they articulated as having a positive effect on their ability to persevere and remain in the engineering profession. Most women found collegiate engineering courses and internships to be most inspiring (Table 1). Learning from experts and applicable experiences in the field (e.g., an apprenticeship) is important to many professions, and explicitly for engineering by providing the learner experiential learning to develop cognitive, formative, visible, and social experiences to be successful in the field (Goodyer & Frater, 2015). According to Bourdieu and his concept of habitus, our (professional) choices, which we may regard as liberally made, are in reality the product of the relations between our innate dispositions and societal embodiment and our desires. The initial life conditions we are born into have a necessary impact on our educational and professional choices, and on our natural inclinations. Our reality is both produced and delimited by our 'sign system', our culture, the resources or capitals we have been allocated, and our position in the field (Webb et al., 2002, p. 33). As Bourdieu predicted, our background experiences have an outsize importance for our resources, our desires, and our abilities to make our ways in the world. Mentorship experiences mattered for these women. This is unsurprising because Engineering U.K. (2018) has extolled the importance of apprenticeship for women in engineering. Specifically, research from the U.K. 2018 study mentioned above shows that there is a need to "increase awareness and improve perceptions of apprenticeships as a worthy alternative to a university education – and to ensure the apprenticeships on offer are of high quality" (p. 14). The results from Table 1 show how women ranked the experiences that helped them build the necessary capital to persist in engineering. The findings from that table help support previous research by Lord et al. (2009) who found that if women were able to matriculate to university-level engineering (and likely partake in application experiences with experts), they were more likely to persist in the field.

A lack of information may preclude many women from choosing a career in engineering. An engineering apprenticeship at a fairly early age may provide an opening for many women who had never even considered becoming an engineer because they had no role models, no support network, nor knowledge about the profession—in other words, they have had no idea what an engineer does. Evetts (1993) found that English women engineers cited their early educational peers and work experiences as important influences for their decision to pursue engineering. Perhaps the most intriguing finding regarding capital is the lack of importance for primary and secondary after-school experiences. Women who reported having them (e.g., science and/or engineering out of school programs) ranked them highly, yet the clear majority of sampled women indicated these experiences were not available to them. This is interesting, as capital-building engineering experiences can begin at any time in a woman's academic career. A recent survey from Microsoft found that girls' interest in STEM subjects arises around the age of 11 and it is often lost by the age of 15, in both the U.K. (Trotman, 2017) and the U.S. (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Research suggests engineering gaps are largely due to a lack of pre-college engineering experiences (Shi, 2018), affirming that secondary engineering experiences have positive effects on developing women's interest and engagement in engineering careers (Bystydzienski, Eisenhart, & Bruning, 2015), likely addressing the 'non-visibility' of engineering careers women report as early career options (Hodgkinson, Khan, & Braide, 2019).

With regard to the effect of peers or other individuals' effects on the careers or aspirations of our participants (Table 2), the results were mixed as to which individuals aided or hindered women's entering and remaining in engineering professions. Parents and college professors did play a central role in inspiring participating women to become (and likely remain as) an engineer. This is supported by additional research on the importance of developing family capital (Martin, Simmons, & Yu, 2013) and university capital (Brown, Flick, & Williamson, 2005) in engineering and for engineering students. Although the sampled women were not asked to disclose any class-based demographic information to minimize the concern of *stereotype threat* influencing survey responses (Davis & Silver, 2003), we theorize that the social capital and cultural capital associated with white-collar social classes and high socioeconomic status (SES) would have had a significant effect on the persistence of women in the field; and this is supported in the literature (Fouad et al., 2016). Further, by the types of questions we posed to participants, we can indirectly glean attributes of class (e.g., capital and habitus), specific to engineering experiences. We believe, based on previous studies, that women who persisted likely also had high SES or cultural capital that aligned in certain ways with the norms, tastes, and expectations of the field of engineering as a workforce. Our respondents expressed that mentorship was very important and this is affirmed by research from Gelles, Villanueva, & Di Stefano (2019) who studied mentoring relationships between engineers and women graduate students in engineering and their students, suggesting that the quality of the mentor relationship had a major influence on their inculcation into the field. While mentorship is important, it cannot be the only cause of persistence. This is where further study is vital. Our results showed that, while most women felt that their parents and background was paramount for them persisting in the field, there were other women who reported negative family experiences and yet also reported an ability to persist in the field. We theorize that this experience might allow future research to parse the difference between families as mentors and families as wells of cultural capital and other cultural resources. However, our current data set did not provide enough information to elucidate this point.

We may surmise the subconscious habitus (e.g., *bodily hexis*) from querying the perceptions of these women regarding their profession (engineering) and interactions with other professionals (engineers). Meaning, we may view how their prior experiences have cultivated their perceptions that are embodied within their interactions and behaviors in the profession through their perceptions of engineers (Table 3) and engineering (Table 4). Notably, women reported words related to being extroverted (e.g., dependable, clever, intelligent), open (e.g., thinker, creator), and conscientiousness (e.g., organized, hard-working). Although these attributes have been empirically identified as gendered personality traits (Schmitt et al., 2008), being more prevalent among women as compared to men, they seem to dovetail well with the emergent needs of dispositions warranted within engineering (National Academy of Engineering, 2004; Rehman et al., 2012).This is particularly salient in the women's responses on engineering itself in Table 4, regarding the mindset, as well as individual and team skills merited as important to the profession.

Limitations

Because of the small sample size that exists at this time, the generalizability of this research is limited. Plus, due to the nature of self-reporting, there may be issues of selective memory and exaggeration, especially in reflecting upon capital and habitus experiences, as well as a potential for self-selection bias. Regarding the findings, some women identified as non-white, which may suggest they have had a more complex experience as a working engineer than other women within the same sample (Dutta, 2015; Samuelson & Litzler, 2016). Women of color would have to contend, more so than white women, with the mismatch between their cultural capital and embodied habitus with the white and male dominated field of engineering. Also, the roles of class (Archer et al., 2012), race (Ross & Godwin, 2015), and other forms of intersectionality (Tao & McNeely, 2019) were not explored, which previous research suggests are factors for women's interest and persistence in engineering (Torre, 2017). We had received responses from a variety of states in the U.S. with large engineering firms and academic centers for engineering (e.g., Florida, Colorado, and Texas); alas, those perspectives do not encompass all experiences of women engineers, especially those at smaller, non-for-profit engineering firms or women's experiences in the U.K. Future research would certainly include a larger sample size of active U.S. and U.K. women engineers, and additional background information (e.g., social class data) would be collected. This research is ongoing, and with a greater number of participants, as well as a stronger contingent of participants from the U.K., we hope to eventually offer more robust analysis of the differences in experience between the U.S. and U.K. contexts. For the purposes of this paper, we did not have enough data from the UK context to draw useful conclusions, so the paper focused more broadly on a Western context and the shared, gendered experiences of our participants. Because access to working women engineers across the U.S. and U.K. precluded qualitative data collection (e.g., interview, focus groups, document-based data), collecting this data will provide greater understanding to these findings.

Conclusion

The paper highlighted the gendered experiences and perceptions of women who persisted in the engineering profession in the U.S. and U.K. Both are consolidated western democracies comprising two of the most powerful economies in the world; yet, both countries' economies are dependent on the engineering industry. In the U.K., the engineering sector contributes 26% of the country's GDP or £127,580,000,000 to its economy (The Institution of Engineering and Technology, 2015; WES, 2021). In the US, despite comprising only 5% of all U.S. workers, engineers are responsible for more than half of economic expansion (Population Reference Bureau, 2012 as cited in Idugboe, 2016). However, neither the U.S. (Dougherty, 2019; National Academies of Sciences, Engineering, and Medicine, 2017) nor the U.K. (The Institution of Engineering and Technology, 2017, 2019; WES, 2021) are producing sufficient numbers of skilled engineers. Furthermore, women engineers eschew targeted programs to enhance women in the engineering workplace, perceiving them as contrived and discriminatory in college (Dutta, 2015) and career (Hodgkinson et al., 2019; National Academies of Sciences, Engineering, and Medicine, 2019). Hence, support-oriented programs are not a panacea for ensuring gender parity in engineering. Based upon our Bourdieusian framework and data, we suggest developing internal factors to develop women's engineering perceptions. Compared to Bonaldi and Silva's (2014) scholarship, in which they had found that the development of men's engineering habitus began from "early socialization experiences within the family, school, peer group and technical schooling;" we found that among the sampled women, their engineering habitus development was stymied by a dearth of prior engineering experiences and complicated by social structures in their schooling. They found that women held "a particular kind of habitus, composed of dispositions, inclinations and competences of the traditionally masculinized engineering habitus, along with inclinations, interests and dispositions generally associated with the traditional cultural repertoire of women" (p.157), which could explain how women differentially come to understand and conceptualize their belonging in engineering spaces. Like Bonaldi and Silva, we too found that despite an inconsistent or abject lack of capital-building experiences and varying habitus-based supports for engineering, women persisted. Further, we were able to extend Bonaldi and Silva's conclusions by evidencing *how* women were able to conceptualize their belonging by holding positive perceptions of the engineering field, which likely contributed to their persistence.

This paper offers an intriguing glimpse into the ways that perceptions, blending with habitus and capital, nurture the 'professional self' that aided sampled women's persistence in engineering workplaces. We hope that this preliminary reporting in part addresses the call for more in-depth research on gender-based experiences of women within the engineering field, rather than focusing on masculine structure of engineering. By focusing on women's habitus- and capital-based engineering experiences and perceptions of themselves, others (engineers), and the field, from women who are active and successful engineers, we may better visualize pathways for their continued persistence. Therefore, these results provide preliminary insights for policy and practices that lead to "improvements to the culture in engineering workplaces, [to] prepare students for gendered workplaces and support students…during and after workplace experiences" (Male, Gardner, Figueroa, & Bennett, 2018, p. 360). Garnering a better understanding of the gendered experiences and pathways in engineering may allow both educational institutions and engineering companies to respond in ways that reflect women's experiences and facilitate the development of STEM pipelines and retention activities that support gender parity. More needs to be done to actively push against gendered inequality in the field from within.

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Appendix A:

What 3 words come to your mind when you think of "Engineer?" (N=90)

Word	Frequency	Percentages
Builder	2	2.222
Inventor	1	1.111
Designer	1	1.111
Skilled	1	1.111
Optimizer	2	2.222
Problem-solver	4	4.444
Highly Educated	1	1.111
Dedicated	2	2.222
Progressive	1	1.111
Intelligent	4	4.444
Math	3	3.333
Knowledgeable	2	2.222
Practical	3	3.333
Organized	1	1.111
Smart	9	10.00
Quick	1	1.111
Person	1	1.111
Degree	1	1.111
Quiet	1	1.111
Reserved	1	1.111
Sensible	1	1.111
Understanding	1	1.111
Collaborative	1	1.111
Calculated	1	1.111
Stuffy	1	1.111
Exhausted	1	1.111
Respect	1	1.111
Analytical	1	1.111
Pride	1	1.111
Hard hat	1	1.111
Drawings	1	1.111
Calculator	1	1.111
Hard worker	1	1.111
Good position	1	1.111

Pretentious	1	1.111
Male	1	1.111
Endeavor	1	1.111
Creative	3	3.333
Computer	1	1.111
Technical	2	2.222
Problem addicted	1	1.111
Man	1	1.111
Glasses	1	1.111
Oscilloscope	1	1.111
Logical	4	4.444
Efficient	1	1.111
Design	1	1.111
Improve	1	1.111
Meticulous	1	1.111
Driven	1	1.111
Changemaker	1	1.111
Me	1	1.111
Dependable	1	1.111
Trustworthy	1	1.111
Insight	1	1.111
Thinker	1	1.111
Scientific	1	1.111
Persistent	1	1.111
Creator	1	1.111
Clever	1	1.111
Confident	1	1.111
Solutions	1	1.111

Appendix B:

Tally: What 3 words come to your mind when you think of "Engineering?" (N=90)

Word	Frequency	Percentages
Fixing	2	2.222
Problem-solving	7	7.778
Math	5	5.556
Solution	3	3.333
Application	1	1.111
Structures	1	1.111
Function	1	1.111
Automation	1	1.111
Precision	1	1.111
Building	3	3.333
Technical	3	3.333
Innovation	7	7.778
Creativity	2	2.222
Usability	1	1.111
Collaborative	1	1.111
Difficult	1	1.111
Open-ended	1	1.111
Science	1	1.111
Work	1	1.111
Diligence	1	1.111
Pragmatism	1	1.111
Skepticism	1	1.111
Steady	1	1.111
Focused	1	1.111
Independent	1	1.111
Asphalt	1	1.111
Sewer	1	1.111
AutoCAD	1	1.111
Iteration	1	1.111
Exciting	1	1.111
Algorithms	1	1.111
Implement	1	1.111

Linkages	1	1.111
Challenge	1	1.111
Industry	1	1.111
Applied	1	1.111
Design	6	6.667
Critical Thinking	1	1.111
Dimension	1	1.111
Technology	1	1.111
Electricity	1	1.111
Improvement	1	1.111
Efficiency	1	1.111
Optics	1	1.111
Device	1	1.111
Communication	1	1.111
Analytical	1	1.111
Complex	1	1.111
Fun	1	1.111
Betterment	1	1.111
Intelligence	1	1.111
Gears	1	1.111
Discipline	1	1.111
difference	1	1.111
Impact	1	1.111
Challenging	1	1.111
Searching	1	1.111
Advancing	1	1.111
Diverse	1	1.111
Team	1	1.111
Coordination	1	1.111