Intelligence and Smartness in Engineering: Gatekeepers to Diversity and Inclusion

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Abstract
The ideas of intelligence and smartness are woven into all levels of engineering education. The individuals who are 1) accepted to study engineering, and 2) persist to practice engineering are broadly recognized as smart. In Western contexts, intelligence is often believed to be a person’s innate and analytical ability, which can be measured by an instrument such as an IQ test and is reflected in grades or standardized assessments. Smartness, on the other hand, is an implicit classification based on collective values, which are co-constructed within a local context. However, these cultural constructions of intelligence and smartness are limited and often lead to negative implications for those who don’t fit the prototypical mold of an engineer (i.e. white, male, and middle class). In this paper we seek to start a conversation about how the construction of intelligence and smartness can act as gatekeepers to diversity in engineering. Further, we aim to discuss the role that we as engineering educators play in the construction of smartness in engineering classrooms. To do so, we synthesize literature related to the construct of intelligence including a brief overview of the history of intelligence, examples of how intelligence has been used as a tool to systematically marginalize the less powerful, and a discussion on the cultural construction of intelligence. We then introduce the idea of smartness, using literature to discuss this construct. We include a synthesis of how smartness has been defined in literature and consequences of smartness in classrooms. We then discuss the implications of intelligence and smartness in classrooms for minority groups in engineering as a result of unexamined normative beliefs that often perpetuate stereotypes. We hope to encourage those in academic and non-academic settings to think critically about how their views of intelligence and smartness could lead to exclusionary behaviors, especially for underrepresented students in engineering.

Keywords: intelligence, smartness, engineering, inclusion

I. INTRODUCTION
What does it mean to be intelligent? How do you know if you’re smart? The terms ‘intelligent’ and ‘smart’ are often used interchangeably in everyday language; however, in classroom settings they have different meanings and are used in different ways. Intelligence is usually operationalized as a measure of how someone performs on some sort of standardized assessment, no matter if the instrument is testing intelligence quotient (IQ) [1], emotional intelligence quotient (EQ) [2], or any one of the other numerous scales designed to measure some aspect of intelligence. While the primary goal of these instruments is to measure a person’s overall aptitude, the idea of intelligence testing has been criticized for reasons such as being inherently biased [3], measuring only specific types of skills and abilities (Sternberg, 2007), and using outdated methodology [4]. In short, measures of intelligence are explicit measures of specific skillsets, which are valued in certain academic contexts.

Smartness, on the other hand, is operationalized in extant literature as implicit theories or ideas about intelligence [5]. Smartness typically manifests itself as implicit judgements we make during
day-to-day, social interactions. In local contexts, such as classrooms, these judgements can result in mutually agreed upon cultural values that allow both students and instructors to categorize members of the classroom into social strata based on their perceived levels of “smartness” [5]. As a result, being considered “smart” in a classroom is often associated with compliance and learned behaviors. Hatt argues that her ethnographic study of smartness in classrooms demonstrates that smartness is not only a cultural practice of social control; it is also a process of ascribing social power along racial and socioeconomic boundaries [5]. So, from Hatt’s research, we might conclude that smartness is a gatekeeping mechanism in schools, and that its use in American classrooms privileges middle-class white students, while being exclusionary to the poor, and to underrepresented minorities. In more recent work, Hatt [6] makes this point more explicitly:

“…grades, test scores, and college preparatory curriculum associated with smartness represent some of the gatekeeping mechanisms…. The students who succeed in getting past the gatekeeping points are told that they have succeeded due to working hard and being smart. The students who fail to pass the gatekeeping points are told that they are lazy and/or not smart enough. In reality, who succeeds past these gatekeeping points is largely connected to race with white students receiving the easiest passes through gatekeeping mechanisms.”

The result, Hatt concludes, has direct implications for diversity and inclusion in that “whiteness and smartness get reproduced” [6, p. 1143].

For the aspiring engineer, being classified as intelligent based on achievement scores, or smart based on informal classroom criteria, affords the label’s recipient certain privileges and opportunities, in the form of things like admission into engineering programs, scholarships, internship opportunities, or potential employment after graduation. Because of this, it is vital that engineering educators be aware of the idea of smartness as a construct that is distinct from, yet related to, intelligence, so that they can begin to 1) reflect on their own beliefs about the relationship between smartness and intelligence, and 2) take responsibility for the ways in which their own participation in the construction of smartness may perpetuate the status quo for participation in engineering. By doing so, we believe that they will be better able to educate in ways that are inclusive. Furthermore, this might allow instructors to adopt classroom practices that promote competence and cooperation as opposed to affirming stereotypes and reproducing maleness and whiteness.

The purpose of this literature review is to begin a discussion of the ways in which both smartness and intelligence are used as exclusionary forces in educational contexts. This review begins with the following contributions related to the construct of intelligence: a brief overview of the history of intelligence; examples of how intelligence has been used as a tool to systematically marginalize the less powerful; a discussion on the cultural construction of intelligence. We then continue with a focus on the construct of smartness including: a synthesis of how smartness has been defined in literature; consequences of smartness in classrooms. To conclude, we provide a section on the implications of intelligence and smartness in classrooms, where we discuss our perspective on how these ideas tie together in a classroom setting. We end the paper by discussing the importance of instructors being cognizant of their own beliefs about intelligence and smartness and how they are constructed in classrooms.

II. INTELLIGENCE
We begin with a discussion on the construct of intelligence. In this section we discuss the history of intelligence, how it has been used, and the fact that it is culturally constructed.

**A Brief History of Intelligence**

The word ‘intelligence,’ at its roots, refers to an innate, general, and cognitive capacity [7]. In other words, intelligence was historically considered to be a capacity that was bestowed onto its recipient at birth, which was applicable in a wide variety of circumstances, and was separate from affective measures. Alfred Binet’s work to measure intelligence in French school children in the early 20th century is considered to be pivotal in the history of intelligence and its measurement [8]. Unlike many of his colleagues who believed that the new and developing intelligence tests could measure something innate in individuals, Binet believed that his scale measured abilities that were informed by environment [7], and that the results could be used to systematically identify inadequate educational conditions [9].

However, the acknowledgement of the role of environmental influences on the development of intelligence was lost when the practice of testing for intelligence was brought to the United States in 1916 by Lewis Terman, a faculty member at Stanford. Terman’s adoption of Binet’s intelligence scale was assumed to be a “technique for revealing intrinsic differences between people in the capacity for learning and reasoning,” and this assumption continues to contribute to commonly held beliefs about mental testing in the United States today [9, p. 8]. Intelligence is usually measured based on an individual’s performance on a standardized assessment, such as the Stanford-Binet or Wechsler Intelligence Scales, and the results are referred to as an intelligence quotient (IQ) because their calculation involves dividing an individual’s mental age by their chronological age.

**Historical Use of Intelligence**

While the primary goal of these instruments is to measure a person’s overall aptitude, the idea of intelligence testing is ubiquitously understood to contain biases. Despite Binet’s initial motivations to improve education for all children, scholars argue that racial and ethnic biases have been central to the use of intelligence testing in the United States [8]. For example, immigration of foreign born people to the United States contributed to the growth of mental testing, as immigrants were perceived as mentally inferior, and tests given at Ellis island were leveraged to confirm this prejudice [9].

This use of intelligence tests began to be leveraged against Americans based on their race and class in the 30s, and test results were used to legitimize discrimination against working-class children and non-white people [9]. In 1969, a controversial article was published, which concluded that differences in achievement between white and black kids have a broad basis in their genetics [10], and this work was used to defend unequal tracking in schools, such as the lopsided placement of black students in vocational tracks [9]. In the years surrounding the release of Jensen’s article, court cases ruled that public schools were systematically disadvantaging black students due to their disproportionate placement in lower ability groups, and that IQ tests were ruled to be culturally biased [7]. Even in the mid-1990s when researchers were acknowledging the role of both genetic and environmental components of intelligence, some continued to make claims about the differences in IQ between racial groups as evidence of biological differences intelligence [11]. Other scholars vehemently opposed this conclusion and pointed out the racist undertones of such work [12].
The Cultural Construction of Intelligence

Leveraging intelligence testing to marginalize the less powerful is linked to the fact that intelligence is a concept that is culturally constructed. Ideas about what intelligence is, and what it means to act intelligent, vary significantly from one cultural context to another [13]. Robert Sternberg argues that intelligence ultimately cannot be understood (and should not be studied) outside of a cultural context because culture and intelligence are inextricably linked [14]. He also argues that how smart someone is judged to be must take into consideration that person’s culture and context, and that our focus on intelligence should be about the achievement of goals rather than meeting a potentially arbitrary threshold of analytical intelligence, as often occurs in our society and in our educational systems.

The link between intelligence and culture is not just theoretical—research has shown that different groups of people have varying conceptions of intelligence, which reflect their cultural values. Okagaki and Sternberg [15] surveyed parents of young students from different ethnic groups and found that minority immigrant parents had broader views of intelligence than Anglo-American parents. More specifically, Anglo-American parents’ conception of intelligence were limited to strictly cognitive abilities while minority immigrant parents also viewed social ability as inherent to what makes someone intelligent [15]. Another important belief that varies across cultures and individuals is about the fundamental nature of intelligence. As theorized and empirically demonstrated by Carol Dweck, most individuals tend towards either a belief that intelligence is static and independent of effort, or a belief that intelligence changes as a function of effort [16], [17]. In general, a belief that intelligence is inherent to the person and independent of effort is common in the United States [17]. Researchers have documented that American born parents believe that a person can be intelligent but just lazy, while Asian-American parents judge how smart a person is based on both innate intelligence and effort—working hard is inherent to being smart [15]. Similarly, a study looking at beliefs about intelligence found that United States citizens were less likely to believe that everyone has the potential to become highly intelligent than individuals from India [18].

In western culture, the intellectual traits that are typically revered can be traced back to the birth of the scientific method during the scientific revolution. From this movement came the idea that any “truth” can be found with rigor, rationality and objectivity. The academic disciplines that idealized these traits were often perceived as more prestigious and to this day, there is still a distinction between what is considered a “hard” or “soft” science based on perceived rigor [19]. This cultural construction of intelligence operates to exclude non-male and non-white individuals. Throughout the history of western academic culture, these valued intellectual traits have often been associated with masculinity and academic disciplines that attract fewer women [19]. In fact, the belief that a field requires innate intelligence has been linked to a lack of woman and minority participation [20].

Oppressive ideas have often been built into scientific practices. For example, scientists in the 19th century used craniometry to create scientific theories that claimed race-based intellectual differences [21]. In recent decades these theories have been heavily disputed, but at the time of their release, the findings were highly regarded; and they perpetuated historical beliefs about white supremacy [21]. We can reasonably conclude that the notion of the objective scientist working in pursuit of universal and verifiable truth masked the biased and prejudicial research practices.

III. SMARTNESS
In this section, we discuss the construct of smartness. We mainly focus our discussion on how various scholars have defined smartness, and the some of the consequences of smartness in classrooms.

Definitions of Smartness

While there are several slightly different definitions of smartness in the literature [5], [22], [23], there is a fair amount of consensus about the ways in which it manifests itself in classrooms. Carrillo posits that instructors “often use performance of ‘smartness’ to identify gifted pupils” [22, p. 72]. He goes on to argue that the performance of smartness is often linked to students’ ability to perform different forms of middle-class cultural capital. So, from Carrillo’s definition of smartness we see two salient elements: being smart is associated with acting out of agreed upon cultural values; and social power dynamics inform who is allowed to be smart.

Hatt’s definition of smartness is slightly different:

“I argue smartness or implicit intelligence is something done to others as social positioning. In addition, I represent smartness as a tool utilized by some not only to determine the social identities of others, but to make sense of their own identity [5, p. 439].”

While we see the two major elements of Carrillo’s definition here, and Hatt’s definition of smartness adds some other features that are useful in distinguishing smartness from intelligence. First, Hatt contextualizes smartness as a verb [5]. Smartness is an action that is done to others in order to impose social strata in the class, but in a specific way. It aims to instruct the student on what smartness is, how they should view themselves, and how they should view others in relation to themselves. This instruction is given to students implicitly through artifacts such as grades, test scores, establishment of accepted behaviors, etc. These artifacts are not established solely by the instructor; they are established by all members of the class. In other words, the nature of smartness lends itself to co-construction of all members of the classroom, even those who are marginalized by this definition. Further, since smartness is implicit and done to others, the behaviors and artifacts that constitute smartness are immeasurable, and as both Hatt [5] and Carrillo [22] argue, they tend to embody Eurocentric, middle-class values.

Leonard and Broderick [23] offer another valuable perspective of what smartness is. They discuss the way in which smartness is constructed as an oppressive force in classrooms. They present the construction of a student as “smart” in a classroom as the result of ideological work, in which some students are taught their intellectual supremacy and entitlement to cultural capital, while others are taught their intellectual inferiority and un-deservedness of cultural capital [23]. The introduction of the language of ideology to the definition of smartness is useful as it brings to the front of one’s mind the dangerous implications of the use of smartness as a social sorting mechanism in classrooms.

Shelby defines an ideology as “a widely held set of beliefs and tacit judgements that misrepresent social realities and that function, through this distortion, to bring about or perpetuate unjust social relations” [24, p. 22]. Using this definition of an ideology, we must view smartness in classrooms as both an ideology and a cultural practice in light of the scholarship on smartness cited above. Furthermore, if it is an ideology and a practice, then we must view all these definitions as conflating to articulate the meaning of smartness, and we can further understand that, as Hatt [5] argues, in classrooms smartness is done to others for the purpose of social positioning.
Consequences of Smartness in Classrooms

Synthesizing our review of different scholars’ definitions of smartness presented in the previous section, we offer our own definition of smartness for the purpose of this paper. We define smartness as an ideological, cultural practice that imposes power and social positioning in classrooms under the pretext of intellectual ability or intellectual capacity. As noted by Hatt, smartness is a verb, not a noun. This definition of smartness lends itself seamlessly to the idea that smartness is culturally constructed because students and instructors alike often use certain interactions and artifacts to co-construct decisions about who is considered smart in both educational and professional environments. In educational environments, this allows smartness simultaneously to serve as a form of capital, and to be used as a tool to categorize students [5]. This can have implications for students’ future schooling, employment, and life outcomes. Marginalized student groups are typically the ones who lose in this process.

Why is smartness so influential in imposing power and social positioning onto students in classrooms? Hatt argues that the reason lies in the idea that smartness acts as a figured world in classroom environments [5]. Figured worlds are socially and culturally constructed realms of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others[25], [26]. In other words, figured worlds are “[shared], sociohistoric, contrived interpretations or imaginations that mediate behavior” [25, p. 52] which can inform the outlooks of their participants. Holland posits that continuous participation in a figured world is what leads to that world becoming sensed and embodied.

The concept of a figured world can be applied to educational settings, where one of a student’s most valued attributes is smartness, which is often assessed through the lens of conformity rather than learning or knowledge acquisition. As a figured world, smartness tends to function as a context of meaning within which social encounters in school have significance and people’s positions matter. Activities relevant to smartness (e.g., test taking, “behaving,” assimilating to cultural norms) take meaning from the construct and are situated in particular times and places.

If we accept that smartness is a figured world, then it follows that this smartness is constructed within a given classroom by both the teachers and students [5]. It is the expression of an unspoken collective consensus between all members of the classroom about a set of values that exist in their heads. In other words, the idea of being the smart person in a classroom refers to a shared mental model that is co-constructed between all members of a classroom (students and instructors alike) that can be used as an informal mechanism for classifying students in a socially hierarchical fashion. The strange thing about smartness is that it is willingly co-constructed by both the oppressor and the oppressed.

While smartness is socially constructed, and has context-dependent meaning, it has very tangible consequences in schools. As Lenardo and Broderick assert:

“A substantial part of the ideological work of schooling constructs and constitutes some students as ‘smart,’ while simultaneously constructing and constituting other students as ‘not-so-smart’—that is, some students are taught their intellectual supremacy and concomitant entitlement to cultural capital, whereas others are taught their intellectual inferiority and concomitant lack of
entitlement to both an identity as a ‘smart’ person, and the cultural and material spoils that such an identity generally affords” [23, p. 2214].

In other words, smartness does little more than stratify privilege in classrooms. The stratification imposed on students by smartness is not dissimilar from stratification imposed on these students by race in society [5]. Furthermore, it has been suggested that artifacts of smartness, such as grades, test scores, and college admissions can serve as gatekeepers in academic contexts [5], [6].

IV. IMPLICATIONS

We now provide our synthesis of the relationship between the constructs of intelligence and smartness. Further, we detail some risks of perpetuating normative beliefs about these constructs.

Characteristics of Intelligence and Smartness

Intelligence and smartness, as described from extant literature above, tend to serve as gatekeepers in American classrooms. Because of their salience in education, and particularly in engineering education, we synthesize the major characteristics that distinguish each construct in Table 1. Intelligence tends to be operationalized as a measure of a specific skillset at a given time (i.e. IQ tests that are applied internationally). The instruments used to take this measurement, however, are typically developed by dominant groups. The means of assessing intelligence in academic settings are standardized, and the results of such assessments have consequences such as educational tracking or acceptance into certain academic programs. Smartness, on the other hand, is operationalized as an informal mechanism for classification based on collective values co-constructed by local groups (i.e. teachers and students in classrooms). Smartness manifests itself through artifacts that can be measured (i.e. test scores, grades, etc.) as well as informal assessments (i.e. compliance, “good” behavior, etc.) with the ultimate outcome being social positioning, or reward in the local environment in which smartness has been constructed.

Table 1. Distinguishing Characteristics of Intelligence and Smartness

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intelligence</th>
<th>Smartness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operationalization</td>
<td>Formal measure assessed at a given point in time</td>
<td>Informal mechanism for social classification based on collective values</td>
</tr>
<tr>
<td>Source of Construction</td>
<td>Dominant groups</td>
<td>Local groups</td>
</tr>
<tr>
<td>Grain Size</td>
<td>Global</td>
<td>Local</td>
</tr>
<tr>
<td>Means of Assessment</td>
<td>Standardized and well-established instruments</td>
<td>Standardized tests and informal interactions</td>
</tr>
<tr>
<td>Outcomes/Implications</td>
<td>Educational tracking, acceptance into academic programs</td>
<td>Social positioning in a hierarch of privilege and power</td>
</tr>
</tbody>
</table>

If intelligence and smartness are distinguishable according to these key characteristics, then as educators we should reflect on our own beliefs about the relationships between these constructs as well as our own roles in the ways in which these constructs are leveraged our classrooms. More specifically, we must think critically about how we, ourselves, contribute to the construction of smartness in the learning environments we design and co-construct. If not, then we will continue
to operate on normative beliefs that can have serious implications for our students, some of which are reviewed in the next section.

Implications of Normative Beliefs About Intelligence and Smartness
Leaving our beliefs about intelligence and smartness unexamined with a critical eye risks the ongoing, exclusionary implications of normative beliefs about these constructs. To start, American educational policies tend to place high value on analytical forms of intelligence while diminishing the importance of other valuable forms of intelligence such as creative and practical intelligence [27]. As argued earlier, cultural beliefs about intelligence vary, and therefore educational policies with a single focus on analytical ability have implications for students based on their cultural background. In fact, significant research is virtually unanimous in concluding that the way that students are identified as ‘gifted’ or ‘advanced’ in K-12 education is systematically racist and classist [28], [29]. We can see the implications of this in the fact that achievement of students can be predicted by the degree to which their parents’ values and construction of intelligence align with the teachers, who are often White and middle-class [15]. Furthermore, a study that explored the argument that tracking in high schools is rational because it is efficient concluded that tracking students based on ability actually just works to perpetuate and magnify social inequity [30]. Other scholars who have explored social inequity in American schools have similarly argued that the construction of smartness and educational labels were developed to oppress people based on their race, class, gender, and national character [31].

Just as our society has constructed what it means to be intelligent and smart, it also has constructed dominant stereotypes about intelligence. These stereotypes are often related to race, gender, socioeconomic status, and ethnicity. For example, when researchers asked male and female participants to self-estimate their analytical intelligence as well as their emotional intelligence and whether or not they believed their father or mother to be more analytically or emotionally intelligent, they found that men self-estimated higher analytical intelligence, women self-estimated higher emotional intelligence, and both genders believed their fathers to be more analytically intelligent and their mothers to be more emotionally intelligent [32]. This finding exemplifies the stereotype of analytical thinking as a masculine trait and emotional thinking as a feminine trait. While the stereotype may not be inherently harmful, when combined with the construction of intelligence as analytical ability, it results in the normative cultural belief that women are not as smart as men.

Stereotypes about intelligence have very real effects on people's educational experiences. These consequences are visible in a collection of personal narratives and qualitative studies on the experiences of women of color in higher education, who have confronted significant personal and professional hardships due to assumptions about their competence [19]. For example, a Latino female college professor described her experience with student’s evaluation forms stating that they were “pleasantly surprised” with her competence as an instructor—this comment implies that the students didn’t expect her to be intelligent [19]. Another example in the chapter titled “They Forgot Mammy had a Brain,” discusses one African American woman’s experiences with the following challenges: constantly being viewed as the "other," lacking support, undergoing excessive scrutiny and an unstated requirement to work harder to gain recognition, tokenism, and enduring assumptions that she acquired her position through affirmative action rather than being qualified [19]. This further demonstrates the ways in which societal stereotypes about who is intelligent enough or smart enough interlock with our cultural constructions of intelligence and smartness in order to marginalize non-male and non-white individuals.
Further, stereotypes about intelligence in combination with the narrow view of intelligence recognized by our schools’ systems leads to exclusionary behaviors that have significant implications for underrepresented students. For example, underrepresented minority students can be systematically marginalized out of certain educational opportunities considered to be reserved for the “intelligent” students. It has been argued that educators tend to possess a deficit orientation toward students from ethnically underrepresented backgrounds, and that this thinking has hindered students’ admission into their gifted programs in school [33]. Even once accepted into gifted programs, teacher’s perceptions of certain students can lead to additional marginalization and challenges for the underrepresented students. For example, black women in a STEM undergraduate program at a predominately white institution were found to face additional challenges since giftedness is culturally constructed as white, male, middle-class [34]. Such exclusionary behaviors also have implications for the classroom and school culture as they then perpetuate stereotypes. Classroom culture matters because how we teach a content area directly influences the identities that are celebrated and who is allowed to hold a position such as of scientist or engineer [35]. Having demonstrated the known risks of leaving our assumptions and beliefs about intelligence and smartness unexamined, we posit that engineering educators might reflect on their own beliefs by asking themselves what they believe about the relationship between intelligence and smartness.

Possible Relationships between Intelligence and Smartness
One goal of this paper is to start an explicit conversation about how the construction of intelligence and smartness can act as a barrier to diversity in engineering. We offer a charge to the reader to think critically about how they view the relationship between intelligence and smartness, considering the operationalizations provided in Table 1 above. As displayed in Figure 1 below, we hypothesize several models for ways in which people could potentially perceive the relationship between intelligence and smartness. In example 1, intelligence and smartness are equivalent meaning that one’s performance on a standardized test at a given period in time is a measure of their overall smartness or potential, and that this reality is independent of the local ways in which smartness is co-constructed. Example 2 depicts intelligence as a subset of smartness, indicating that they are related to each other, but that a person’s measured intelligence is not the sole determinant of the level of smartness assigned in local and social contexts. In example 3, intelligence and smartness overlap, and both are considered equally important constructs with an overlap in some of their characteristics. In other words, the two constructs have some areas of overlap but also some areas of distinction. Finally, in example 4, intelligence and smartness are mutually exclusive meaning that an individual believes that one’s performance on an intelligence test is totally independent of their smartness as assigned through local interactions in a given context.
Strengths and Weaknesses of Possible Models Based on Prevalent Scholars’ Perspectives

To further elucidate the relationships between intelligence and smartness expressed in Figure 1, we offer descriptions of where we believe three leading scholars on smartness and intelligence fit with respect to the models we offer.

First, we consider the work of Robert Sternberg [36] who posits a theory of ‘successful intelligence,’ in which analytical intelligence runs parallel (and is of equal value) with both creative and practical intelligence. Sternberg also has significant work arguing for the requirement of cultural considerations in the study and discussion of intelligence [13], [14]. Based on his argument to extend the recognition of analytical intelligence or academic intelligence to include other culturally relevant forms of intelligence and therefore be more equitable, we hypothesize that he might be most aligned with Example 3, where smartness and intelligence have some overlap (analytical intelligence), but also have independent components, including the ‘objective’ or ‘innate’ measure of intelligence (which he would dismiss) and the assignment of smartness ascribed in the context of a given culture or setting.

For our next example, we consider Beth Hatt’s work in order to hypothesize her view of the relationship between intelligence and smartness. In much of her scholarship on smartness, Beth Hatt argues that measures of intelligence (test scores, grades, etc.) are artifacts of smartness [5], [6], [37]. She also argues that these artifacts serve as one of many factors a classroom uses to co-construct the figured world of smartness. In this way, we would argue that Hatt’s views on the relationship between intelligence and smartness would fall into example 2. Her work seems to indicate that she considers intelligence to be a subset of a collection of factors that make up smartness.

Finally, Carol Dweck posits a theory of fixed and growth mindset as the belief one has regarding the nature of intelligence or ability. We associate example 1 with someone who has a fixed
mindset. A person with a fixed mindset believes that intelligence is an innate fixed trait [38]. We equate this to a person who would also believe that the performance on a standardized intelligence test would represent someone’s overall smartness. This view is deterministic, can be exclusive, can perpetuate stereotypes and can be destructive. We associate a growth mindset, the belief that intelligence can be developed [38], with any of the three remaining examples. These three examples don’t limit overall smartness to the performance on a single standardized intelligence test meaning that one can always develop or grow. We believe these views of the relationship between intelligence and smartness lead to more inclusive outcomes. However, we do acknowledge that these views, in particular example 4, would make it more challenging to measure ability or performance in any sort of academic setting.

V. CONCLUSION

This review has provided insight into the ways in which both intelligence and smartness have been operationalized in extant literature, synthesizing the major defining characteristics of the two. We also reviewed research that demonstrates the danger of operating on normative beliefs about intelligence and smartness, which can be summarized as exclusionary to non-majority individuals, such as women, people of color, and people of lower socioeconomic statuses. We then proposed a model, to serve as a tool for readers to reflect on their own beliefs about intelligence and smartness. These are such salient constructs in engineering, and they operate as gatekeepers for who participates and who is recognized as “capable” in engineering education. This tool (see Figure 1) can be used in an exercise of self-reflection around one’s own beliefs about the relationship between intelligence and smartness.

An understanding of how intelligence and smartness are constructed as well as active reflection on our own view(s) of the relationship between these two constructs can help us better understand how we are active participants in processes that either validate or invalidate students’ abilities, in our own practice as educators. This is of vital importance because of the implications that the exclusionary nature of smartness and intelligence can have for students, particularly underrepresented minorities. Students are constantly receiving messages about where they stand and whether or not they belong. These messages are received both in our classrooms and in society. This is of particular importance for educators wishing to increase diversity and inclusion in engineering because the messaging students receive about ability inside the classroom is partially influenced by the instructor. We believe that if the instructor has some explicit understanding of the construction and use of smartness in his/her classroom, they are more likely to behave in ways that promote inclusion and provide positive messages to members of the classroom regarding who is smart enough to be an engineer, with a particular focus on perpetuating typecasts about engineering competencies that are not exclusively synonymous with male, white or middle-class ideologies.

For readers who are not classroom instructors, we believe that being mindful of how smartness is culturally constructed can help you better understand how you participate in a co-construction of smartness that may be exclusive, especially with respect to the cultural barriers inherent to ability present for underrepresented students in engineering. In the end, we all must take responsibility because we participate in the construction of smartness. It is our hope that this work can help encourage those in both academic and non-academic settings to reflect on how they contribute to this potential gatekeeper and how their tacit assumptions about intelligence and smartness may be antithetical to welcoming and inclusive environments.
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