

Think-Aloud Insights: Exploring QuantCrit Challenges and Diverse Survey Responses Among Undergraduate Engineering Students

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Introduction

Diversity in engineering contributes to social and economic advancement in communities by offering varied perspectives on problems, better reflecting changing demographics, and providing tangible business advantages. Higher education is vital in addressing this need as it prepares future engineering researchers and practitioners. Despite increased representation of minoritized individuals in recent years [1], statistics show that women and other minorities (e.g., racial, ethnic, gender, socioeconomic), are less likely to pursue graduate school compared to their White male counterparts. Prior literature exploring the experiences of undergraduate minoritized students tends to focus on deficit-based perspectives, such as lack of language proficiencies and difficulties assimilating to university culture [2]. While acknowledging these barriers is important, understanding the skills and knowledge these students hold and how they use these assets to navigate their institution can provide a clear, tangible, and actionable means for universities to provide avenues of support for minoritized students while challenging deficit views of these students.

A similar demographic trend has been observed and is the focus of this work within a large land-grant university's Mechanical and Aerospace Engineering department, where Latiné students represent approximately 20% of the engineering undergraduate enrollment. However, these statistics lack meaning without historical, racial, social, and political context. To address this and better understand the phenomena, we use a Quantitative Critical (QuantCrit) perspective to combine Tinto's Collegiate Achievement Model with Yosso's Community Cultural Wealth (CCW) Model to design a survey on factors influencing undergraduates' decision to pursue an engineering degree. QuantCrit, challenges deficit perspectives through critical methods that interrogate eugenic approaches and perceptions to quantitative data [3]. Given the critical nature of QuantCrit, studying survey design is a worthwhile endeavor as it examines how survey items can be framed to capture nuances in critical research. The research adopts an asset-based approach, using CCW as a theoretical framework, to understand the existing capital—assets individuals hold-- of undergraduate engineering students and how such capital shapes their college experiences and decision to pursue graduate school, while also evaluating the effectiveness of QuantCrit methods in survey design. Given the significance of CCW on undergraduate engineering students' college journey, the purpose of this study is to use think aloud methodology to understand how students' use their capital in their education journey to persist in their undergraduate engineering degree.

The research questions for this paper are:

- What types of community cultural wealth do undergraduate engineering students reference when prompted by a survey question, and how do they describe these forms of capital?
- How do student's interpretations of survey questions highlight the benefits and challenges of QuantCrit, particularly as it relates to tensions between survey items and interpretations?

Community cultural wealth

When examining CCW, it is important to understand how asset-based approaches expand upon traditional theories of capital. Bourdieu's theory of habitus and capital [4] describes one's dispositions that have been shaped over time (habitus) and the social, economic, and cultural resources one possesses such that it promotes one's place in society (capital). However, this theory has often fallen short in representing alternative forms of capital that minoritized individuals may hold [5].

Yosso's CCW Framework [6] challenges Bourdieu's theory by presenting an asset-based perspective on capital. She argues that it is important to recognize the existing capital that minoritized communities have by highlighting the existing social, linguistic, navigational, aspirational, familial, and resistant capital held by individuals in these communities (Table 1). These forms of capital are particularly important for the success of undergraduate engineering students. For example, Dika et al. [7] highlight the significance of aspirational capital for minoritized students in engineering. They elaborate on this finding to emphasize the relationship between social and aspirational capital and its influence on persistence in engineering. Similarly, Tolbert-Smith [8] found that family served to reinforce Black men engineers' resistant and navigational capital by imparting their advice about racial socialization. The finding also reflected a form of familial capital—which can also support students by connecting family engineering knowledge and skills to their college studies [9].

Table 1. Community Cultural Wealth Model

| Capital | Description | Example |
|----------------------|--|--|
| Aspirational Capital | Sustain hopes and dreams and overcoming barriers | Career goals |
| Social Capital | Social network of people and community | Relationship with peers |
| Linguistic Capital | Communication styles and languages | Connect with others with language |
| Familial Capital | Knowledge amongst family and culture | Drawing from community historical and cultural knowledge |
| Navigational Capital | Skills to navigate social institutions | Skills to overcome challenges |
| Resistant Capital | Knowledge and skills to challenge inequities | Responding to negative stereotypes |

Critical quantitative methods

QuantCrit is becoming increasingly favored as a methodology to disrupt White supremacist tendencies in interpreting and communicating quantitative data. Drawing on Critical Race Theory as its foundation, QuantCrit challenges eugenic ways of utilizing quantitative data by emphasizing five foundational principles when adapting a critical theoretical framework to a quantitative study: 1) The Centrality of Racism, 2) Numbers are Not Neutral, 3) Categories are Neither Natural nor Given, 4) Voice and Insight, and 5) Social Justice/Equity Orientation [3]. These principles challenge researchers to reflect on their biases throughout the entire quantitative research process (e.g., design, collection, analysis).

CCW is commonly used as a qualitative framework for research. Such framework views minoritized communities through an asset-based perspective, aligning with QuantCrit's foundational principles. However, given the large influence that quantitative data have on societal changes, and the historical misuse of quantitative numbers for eugenics [3], incorporating CCW in quantitative research is a worthwhile endeavor to counter deficit discourses through the measurement of CCW. Critical Race Theory scholars argue that QuantCrit methodology can serve to amplify the perspectives and experiences of marginalized communities [3]. Together, QuantCrit can provide valuable broader insights on the CCW held and used by students of minoritized populations. One example includes Perez Huber et al.'s [10] use of QuantCrit as a counter story methodology to share the occupational outcomes of Latine students.

Our study explores the use of think-aloud methodology to provide an avenue for integrating the principle of Voices and Insight in survey design. Voices and Insight posits that all data is subjected to socially constructed interpretations, thus prompting researchers to reflect on how their beliefs and experiences shape their understanding of the data [3]. Voices and Insights also recognizes the importance of the knowledge and experiences held by minoritized individuals. Using think-aloud methods provide an opportunity to employ the principle of Voices and Insight to contextualize quantitative data within the experiential knowledge of minoritized individuals, amplifying the experiences of the student participants of this survey.

Positionality Statement

We preface this work with this statement to acknowledge and reflect on our potential biases and subjectivity to this work. This statement may serve to assist readers in understanding possible influences in our process. Ms. Castro is a Latina, first-generation doctoral student and former high school science teacher. Despite not having direct engineering experience, she is drawn to understand and incorporate diverse perspectives within this field. Dr. Carroll is a white male with a tendency toward an emic account from the institutional perspective given his many years in administrative positions. However, he has strong personal sensitivities to individuals and families fighting for rights. Dr. Mejía is a Latina engineering educator and an immigrant in the United States. Prior to teaching in academia, she worked in for-profit and non-profit sectors to optimize technologies, processes, and policies in organizations. She provides unique emic and etic perspectives to the research problem. Dr. Crippen is a white male science educator who champions change in educational systems to meet the needs of every student. He has worked on multiple projects with engineering faculty but views himself as an outsider in engineering circles. All four researchers are committed to embracing anti-deficit approaches of engineering education research for promoting broader, more equitable participation in STEM professions.

Methodology

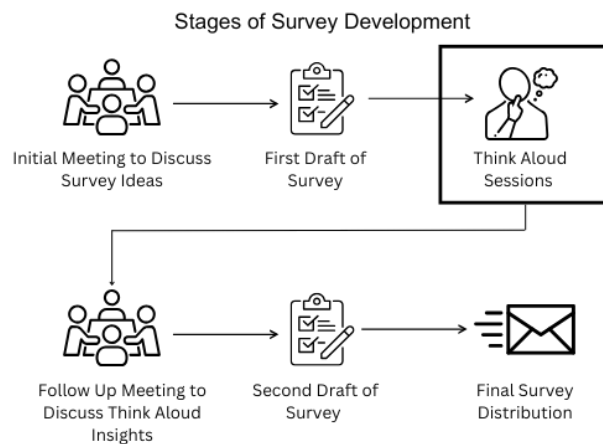
The study is part of a larger mixed-methods research project investigating Latina engineers' career and graduate school decision-making. A survey based on a QuantCrit perspective [11] was designed and distributed as part of the broader project, with questions based on the CCW framework (Table 2). Our survey development was an iterative process (Figure 1). We combined Tinto's College Achievement model and CCW to arrive at prompts related to different forms of student capital. We met frequently to discuss the development of the survey to considering factors such as wording the prompts for

students' understanding. To help us understand how our population would interpret the survey instrument, we conducted think-aloud interviews. The current study focuses on the qualitative think-aloud interviews with six undergraduate engineering students who shared their thought processes while responding to the survey questions to help develop the instrument.

Table 2. Sample Survey Prompts

| Sample Question | CCW |
|---|----------------------------|
| I draw on encouragement from my family to be successful at this university | Familial |
| I have developed strategies to navigate difficult people and situations at this university. | Navigational; Resistant |
| It has been difficult for me to meet and make friends with other students. | Social |

Figure 1. Stages of Survey Development



Qualitative think-aloud interviews allowed for exploring students' thoughts with minimal prompting questions [12]. Though we used purposeful sampling to identify Latinas, we encountered difficulties during recruitment, highlighting the difficulty of conducting equity-centered research with underrepresented communities. Given the need to understand the experiences of underrepresented students, we expanded the study to include students from other minoritized identities (Table 3). The process allowed us to consider intersecting factors such as immigration generation, parental education, and other social identities that may shape students' experiences in their STEM education, thus developing a broader understanding of the capital leveraged by and within underrepresented groups.

Each think-aloud interview lasted approximately 45 minutes to one hour and were conducted by the first author in this paper. During the interviews, participants were asked to read and share aloud what they believed the question was inquiring and then respond to the prompt on a Likert scale to indicate a degree of agreement. To ensure confidentiality, each interview was recorded after obtaining verbal participant consent and then transcribed verbatim using pseudonyms for participants.

Using thematic analysis, we employed a deductive coding approach using CCW (Table 1) as our

coding framework. For example, the code *familial capital* was used to highlight instances where the participant spoke about their family’s role in their college journey. Additionally, to highlight broad themes across participants, we inductively coded for instances where participants’ interpretations of questions differed. For example, we used the code *Confused Wording* to highlight a moment in which a participant voiced being unsure about the wording of a prompt. The transcripts and codes were interpreted holistically, consolidating, reducing, and interpreting participants’ responses with reflective memos [13] using CCW as an analytical framework to guide our findings.

Table 3. Student Demographics

| Student | Major | Year | Gender | Race/Ethnicity | Immigration Generation | Immigration Country |
|---------|------------------------|--------|--------|------------------------------------|------------------------|---------------------|
| Kyle | Biological Engineering | Fourth | M | Asian American | Second | China, Hong Kong |
| Elena | Aerospace Engineering | Fourth | F | Latíné ^a | First | Spain |
| Charlie | Math Education | Third | F | White | N/A | N/A |
| Megan | Mechanical Engineering | Third | F | Latíné, Asian ^b , White | Second | Costa Rica |
| Zoe | Aerospace Engineering | Fourth | F | White | Third | Italy |
| Abraham | Biomedical Engineering | Fourth | M | Black | Second | Nigeria |

^a We use the term, “Latíné” as a gender-neutral term to refer to individuals who identify themselves with Spanish-speaking cultures rooted in South America, Central America, the Carribean, and Europe. We include individuals who identify as “Hispanic” or those who speak Portuguese. We recognize the historical discourse around terms used to describe and categorize people with Latin American ancestry as one rooted in Latin American social movements that challenge problematic origins of terms connected to colonialism and imperialism [14]. While all terms have flaws, we chose the term Latíné as it considers gender-neutral individuals and challenges the colonization of the Spanish language using a term that is phonetically aligned with the language.

^b Student identifies as a second-generation student from Costa Rica, and mother is second-generation from China.

Findings

The findings are presented in two parts, reflecting the research question. First, we discuss how students reference their capital. Then, we contextualize these findings within QuantCrit and examine the results of think-aloud on the implementation of QuantCrit methods.

Faculty, family, and friends as social capital

Participants attributed their success and persistence in school to relationships with faculty, family members, and friends. Their relationships with faculty reflected a form of instrumental social capital related to obtaining resources to achieve a goal [15]. Although all participants believed

professors are interested in their well-being, female participants reported feeling nervous about approaching them. For example, Megan expresses her experiences approaching a professor:

It's pretty nerve-wracking and I know-- I think the reason why I am doing-- I interact--is because it's for all like my career and like to build connections and I know opportunities come with having good relationships of professors for like maybe-- Yeah for overall like career, but it's pretty-- I think it's pretty scary and I really have to like hype myself up before I do anything like talk to a professor—not hype myself up, but just like assure myself and like plan it and like Okay, “here's what I'm gonna say” like in my head.

Megan's recognition of the importance of fostering a relationship with her professors and difficulty approaching them echoes the responses of the other participants, like Elena and Charlie, who describe feeling too shy to approach their professors during office hours. On the contrary, Abraham emphasized his disposition to approach professors without hesitation, jokingly stating, “I just, like, ask. Yeah. Like, what are they going to do? We can fight if they don't like me. [Laughs].”

Despite how the obstacle to approach faculty was described, participants leveraged their linguistic and aspirational capital to help them initiate conversations. For example, participants recognized their ability to communicate in professional settings yet demonstrated favor towards faculty who presented themselves as open to informal conversations. These findings are consistent with prior literature that reveals how faculty play a significant role in engineering student's support in competitive environments such as engineering degree programs [7].

Participants' families served as familial capital through family encouragement, cultural connection, and expectations. This form of capital reflected expressive social capital—related to “physical, mental health, and life satisfaction” [15]. Elena shared that she felt encouraged by her mother through phone calls before exams and care packages from her country of birth. In contrast, Kyle expressed how pressure from his family prompted him to complete his degree in biological engineering and potentially pursue graduate school. While he voiced an interest in carpentry as a career, a comparison with his twin brother, who is currently in pharmaceutical school, communicated a sense of expectation to pursue a career viewed as a “successful option.”

However, students' noticeably spoke less about their families in an academic context. While family served as a source of encouragement, there was limited insight into how family supported students academically. The observation does not imply that family played an insignificant role in the students' academic experiences. Rather, it highlights a limitation of the survey, demonstrating how a simple question was insufficient to capture nuances in students' response. Thus, researchers must consider how questions are worded and interpreted when drawing conclusions on survey responses during data analysis.

Participant's friendships served a unique role, intersecting academic and familial roles in the form of expressive and “instrumental social capital” [15]. Zoe provided an excellent example of this connection when she shared how her friends help her academically and emotionally:

I have various groups of friends, and we all sit down and work out the homework together and we study for exams together. So, like my connections with my classmates, I think of all the groups that I've made and like the group chat-- I have group chats for every class that I'm in and we're all like building each other up and trying to help each other be successful in all our classes. It's not as competitive as I think some other majors might be.

Zoe's words reflect how friends are positioned as a bridge between academic instruction and emotional support. For Elena, friends provided a space for work:

I'm thinking of my friends, my classmates. And I do since last year, I've been at [the library], all day, and working with people-- help so much. Working with your classmates and your friends. I'm like, it helps so much with homework and just motivation in general.

Beyond academic settings, participants described how personal friendships helped them navigate social situations. Kyle noted that while student friendships have helped to support him academically, they also encouraged him to maintain a consistent diet.

Resistant Capital

When asked whether they believed completing their degree would contribute to combating stereotypes about those who share their social identities, participants acknowledged the underrepresentation of their identities in STEM but expressed not viewing it as a significant issue. Similarly, participants believed their peers shared values and attitudes like their own. Although politics was mentioned, it was not seen as important for undergraduate degree completion. Rather, they focused on shared academic values, work ethic, and morals. Contrary to findings in the literature that focus on institutional and social barriers for minority students, the participants provided counter-stories to deficit perspectives. They expressed a different experience, showing minimal focus on existing inequities, and instead voiced feeling comfortable and supported. It should not be interpreted that their resistant capital was lacking. Their participation in racial/ethnic student organizations can be considered resistant capital. Rather, they perceived less need to rely on this resistant capital. Their experiences suggest that they felt supported and comfortable within their educational environment, allowing them to focus on their academic and personal growth without the constant need to confront or navigate systemic inequities.

Leveraging Community Cultural Wealth to form interests about graduate school

While students highlighted different types of capital that encouraged their participation in engineering, most were not explicitly connected to their interest in pursuing graduate school. However, social capital in the form of relationships with faculty, navigational and aspirational capital appeared to be the most conducive to their interest in graduate school. For example, students like Megan and Zoe described how their aspirations to "be successful" led them to consider continuing their studies post-graduation.

The students described developing an understanding what graduate school entails through their interactions with faculty. They utilized their aspirational capital to develop relationships with professors to further their educational goals through research opportunities, career advice, and letters of recommendation. Abraham explained how he was confident in pursuing graduate school because of the extracurricular opportunities he could participate in due to connecting with his professors. His experiences working in a lab allowed him to view himself as a researcher:

Throughout the time I've been here, I would say I've been involved in research and like seeing how it works. And like, I think being getting involved, maybe when I first started it, I'd be like, "whoa, what is research? You do, um, mess with pipette?" Like, it would seem

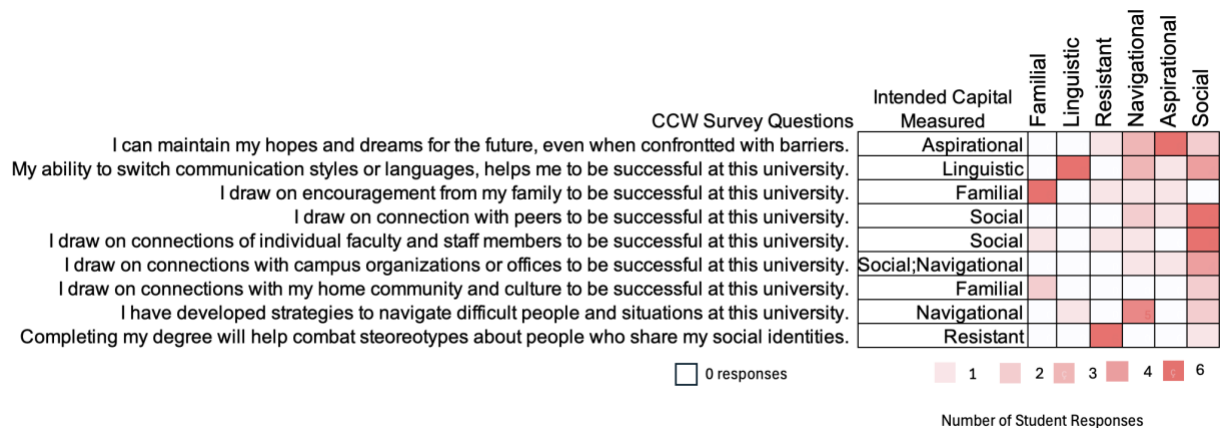
very...foreign to me. Oh, when I first started, but now that I've gotten to dip my toes into it, you're being involved in labs-- As an undergraduate, I would say, it's definitely something that I could do. I'm not doing it, like, right now, but, like, I could do it.

Abraham's experience reflects findings in prior literature that reveal the positive influence lab experiences have on students' aspirations for graduate education [16].

Data cannot speak for itself: voice and insight in QuantCrit

The think-alouds provided insight into how participants perceived the capital that each survey question intended to measure (Figure 2). Our findings revealed that students referenced multiple forms of capital when interpreting the survey items. For example, when asked, "I can maintain my hopes and dreams for the future, even when confronted with barriers,"—a survey question intended to measure aspirational capital—students referenced other forms of capital such as resistance (n=1), navigational (n=3), and social (n=2). Furthermore, in comparing the capital referenced versus the intended capital measured, we can see how some survey questions may be limited in nature. These insights can point to a limitation in the survey instrument itself as well as reflect the nuances of QuantCrit. The following section provides insights into student's interpretations of survey responses, demonstrating how the Voices and Insight tenet of QuantCrit helps to understand the benefits and challenges of using critical survey design to capture cultural and contextual nuances in student's experiences.

Figure 2. Forms of capital referenced by students per survey questions



Diverse Interpretations of the Survey Items Amongst Students and Researchers

Students revealed that survey items were ranked differently depending on their interpretations. Zoe describes her various interpretations of the item, "I can maintain my hopes and dreams even when confronted with barriers," and further explains why:

If we were to look at this socially, I probably say strongly agree, just because of my very specific case where I'm a girl in engineering and aerospace. And that's like what people want nowadays. So I would say that that might have been a barrier, but my hopes and dreams for the future are not tarnished. If we're looking at this academically, I probably

say strongly disagree because if my barriers that I don't have the GPA to like make it a cut off, I'm not going to get into grad school, so like yeah, I don't know-- [my score could] go either way.

Zoe's response highlights how a pragmatic interpretation can lead to score variations. It also challenges assumptions about barriers experienced by women in engineering, revealing a perspective that is otherwise missed by only observing numbers.

In contrast, Charlie's response reflects how her aspirational capital, particularly a person's dispositions, affects her interpretation:

If you like, get a bad grade, or you lose a scholarship, or something like that, or you have a personal issue, you can still like-- it's like your outlook on life. You-- You keep on trying, or if you're like, you have a tendency to give up and stuff. Um, I probably say, agree. I mean, I wouldn't say I'm like, crazy optimistic. Like, I would say, I'm realistic, but don't give up super easily.

Charlie's response reflects the responses of other students who interpreted this question through the lens of aspirational capital. Abraham, on the other hand, highlights the role of navigational capital to overcome barriers, sharing resources available to persist toward his goals.

While this survey item intended to inquire about students' aspirational capital such as their motivation, Abraham's approach focused on his navigational capital. The distinction highlights the principle that numbers are not neutral but rather are nuanced by cultural wealth and personal experiences influencing the interpretation of the survey items. Thus, it is important to recognize how underlying contexts are necessary for understanding how students interpret and score the survey items. Using survey interviews, such as think-aloud, alongside survey data can provide insight into these differences of interpretation, aligning with the goals of QuantCrit.

Researcher Assumptions of Interpretations of the Survey Items

When asked about graduate school, students' responses communicated a lack of knowledge of what graduate studies entail, indicating a disconnect in our and students' perceptions of graduate school. The finding was explicitly voiced by students who described how others might perceive graduate school questions differently. Kyle described the significance of knowing what research entails prior to responding to this question:

I feel like you have to look at this question with...[whether] you've done some research. Like if you've had research opportunities-- because you don't really know what research is, until you've done it yourself. So with that in mind, like if the lay person just comes into like, "oh, I want to do research, or like I don't, I think research is something other people do." Like, you don't really have an accurate representation of research. So I think, understanding what research is first.

Kyle's critique illuminates potential researcher assumptions about students' knowledge of graduate school. It is worth noting that in research meetings, and as the authors of this paper, we discussed how undergraduate students' may be familiar and understand different types of graduate programs and how to convey that information in the data collection instruments. As a result, we modified the survey to include descriptors of different degrees obtained in graduate schools

including non-research-based degrees like Master of Business Administration, and research-based degrees, such as Doctor of Philosophy. Although the process aligns with a core tenet of Quantcrit, Interrogating Researchers' Biases and Assumptions, the use of academic terms related to graduate school remained an issue for students reviewing the survey questions. The finding also highlights how the phrasing of survey items may be influenced by researcher bias and, thus, must be examined to design and present surveys that are relatable to the students.

Varying Scores

Throughout the think-aloud sessions, students often were between scores, demonstrating varying interpretations of the Likert scale. A frequent diverse use of the neutral score *three* was voiced by students. This neutral score, described as "not sure," was often chosen when the student was unsure of their response, lacked enough information to decide, or felt confused about the question. For example:

Megan: "[Reading survey item] I'm interested in earning a non -research -based graduate degree." I'm not sure. I didn't really realize there is research -based and non -research -based graduate degrees, really. It's kind of the first time I'm reading this--And I guess-- I guess I don't know much about this topic.

Researcher: What would you give it knowing what you know?

Megan: I'm not sure, three?... I understand what the question's asking, but my background knowledge about this is not--I don't have much background knowledge.

Similar to other students, Megan was unsure of the differences in graduate degrees. As a result, she chose to rate the survey item as *not sure*, due to a lack of background information she perceived was necessary to score the item.

Additionally, students often shared similar reasoning, experiences, and interpretations to the survey items, yet, varied in their chosen score. Zoe and Elena provide an excellent example highlighting how numbers provide limited understanding of participants' realities. Both Zoe and Elena participated in extracurricular activities including becoming teaching assistants, conducting research, and participating in extracurricular activities. However, Zoe often scored survey items about success at the university and interest in graduate school as *strongly agree*, the highest score. Elena, however, while using the same reasoning, tended to score closer to neutral, demonstrating a potential central tendency bias by avoiding extreme scores.

These instances prompt researchers to reflect on how participants' interpretation of the Likert scale compares to ours. Developing a nuanced understanding of how our participants will perceive and utilize the scale can encourage us to think through alternative interpretations of numeric values. The finding also raises the question on the validity of Likert scales, as they may be perceived differently across different demographic populations. When implementing Likert scales, it may be worthwhile for researchers to examine how the interpretation of the scale itself may lead to varying scores that do not accurately represent the responses of all students. Researchers may consider implementing a thorough description of the Likert scale values when distributing surveys, as well as incorporating brief instructions for how students should respond when unsure of the survey prompt.

Conclusion

While the think-aloud interviews were initially intended to help us modify and finalize the survey for the larger study, the findings provided an avenue for students' voices to be heard outside of numerical values and in the research and data collection protocol design. Through these interviews, students expressed their experiences, revealing the different forms of capital used throughout their undergraduate studies. The interviews also allowed for participants to contribute their feedback on the survey design that was part of the stages of survey development. By incorporating the QuantCrit emphasis on elevating marginalized voices within the research process, we were prompted to revise survey questions such that they are more accessible and understandable for all students, and to better understand the phenomena under investigation in the research questions. The process included adding descriptors for prompts that may be confusing for some students (e.g., elaborating on graduate school programs). Although our participants provided valuable knowledge, the sample size was limited. Future research studying these experiences can benefit from a larger sample size with a greater representation of minoritized demographics, and specifically within the specific participant population. Such research can serve to avoid the generalization of student's experiences and provide additional insights into how students interpret surveys rooted in QuantCrit methodology.

The think-aloud study contributes knowledge of the factors that support college engineering students and the capital they draw on for their success. The insights can inform universities for the development of programs that foster networks of support (e.g., faculty-student relationships). In addition, this study demonstrates the value of think-aloud as a tool for evaluating QuantCrit surveys. It emphasizes the use of Voices and Insight to provide minoritized individuals' experiences in the context of quantitative data. Researchers may consider implementing think-aloud methods as a tool to guide the design of surveys and qualitative studies, including those within explanatory sequential mixed- methods. We plan to use these insights to inform the second phase of the project, and the quantitative analysis of our survey results.

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