Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #48073

Exploring Engineering Perceptions Among First-Year Undergraduate Students from Low-Income Schools: A Mixed Methods Study

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Exploring Engineering Perceptions Among First-Year Undergraduate Students from Title I Schools: A Mixed Methods Study (Work in Progress)

Introduction

The goal of this work-in-progress study is to examine students' perceptions of engineering based on their high-school environments. Specifically, we seek to understand differences between low and high SES students who attended Title I vs. non-Title I schools. Title I schools are part of a federal program that provides financial aid to low-income families in specific areas below the poverty line. Students who attend these schools often confront many barriers, such as a lack of college exposure, resources, low quality educational structure, and socioeconomic factors [1]. Title I students often experience a deficit in resources and exposure to post-secondary education preparation; the lack of exposure can leave students unaware of the college process as well as unprepared for future careers and classes [1]. This can lead Title I students to being heavily disadvantaged regarding college readiness when compared to higher-income schools. Understanding the difference between low and high SES will give us a better perspective on the effects of low income vs. poor educational structure.

Research has found that exposing more Title I students to engineering can boost their confidence [2]. Understanding students' perceptions on engineering from Title I and non-Title I (low and high SES) will show how effective engineering coursework can be in high school [3]. Therefore, it is important to consider why aspects of engineering may resonate with this specific population compared to others.

The following sections will first detail the framework we used to guide our study. We then detail the Q-methodology, the method used in this study. We will present our current progress (development of Q-statements) before discussing our conclusions and future work. We will then end with a self-reflection of the first author's experience doing this work.

Guiding Theoretical Framework

This work was guided by Eccle's Expectancy Value's Theory and Subjective Task Values (EVT-STV). EVT provides a robust framework for analyzing how students' beliefs about their ability to succeed (expectancy for success) and the value they assign to academic tasks (subjective task value) influence motivation, engagement, and achievement [4, 5]. This study leverages EVT to explore the experiences of first-year undergraduate engineering students from Title I public schools, examining how socio-economic barriers and resource limitations intersect with academic aspirations and career motivations. EVT was chosen because it provides us with crucial information on specific emotions related to students' insecurities, worries, mentorships/relationships [6], and confidences on a personal and academic level. the field of engineering. EVT constructs such as utility value (e.g., engineering's relevance to future goals) and perceived costs (e.g., inadequate resources) offer a structured lens to understand disparities in access to engineering-related opportunities, such as specialized courses, clubs, and career exposure [7]. The theory also informs the development of the Q set, enabling the capture of nuanced perceptions and motivations that drive students' engagement in engineering despite systemic inequities [8]. By emphasizing individual motivation alongside systemic factors, EVT guides this study in proposing targeted educational reforms that enhance engineering-oriented thinking, validate the creative and problem-solving potential of underserved students, and advocate for equitable access to STEM careers. Table 1 outlines the core concepts of EVT-STV.

Table 1. Reference used for developing Q-statements based on Eccle's Expectancy Value's Theory and Subjective Task Values [9].

Concept	**Definition**
Expectancies for Success	How well do you expect to do on a task? If you believe you will succeed, you're more likely to want to do it.
Attainment Value	Value associated with a task's relevance to some/multiple aspects of your identity.
Intrinsic Value	Do you do something simply because you enjoy doing it? Enjoyment out of a task.
Utility Value	Will this be useful in the future? Usefulness in general.
Cost	The cost associated with a task. Opportunity cost is another type of cost and is the opportunity you lost by making your choice.

Methods – Q Methodology

Q methodology

Q methodology is a mixed methods approach uniquely suited for capturing and analyzing subjective viewpoints. In this study, it will be used to explore key stakeholders' perspectives on their academic experience; specifically, first-year students from Title I schools perspectives on engineering. The methodology is centered around a Q-sorting process. The Q-sorting process consists of participants sorting and ranking a pre-defined set of statements about a certain topic or subject based on how much they agree with those statements to a given prompt. The pre-defined set of statements is called a Q set, and they are designed in a way to make participants reflect on their experiences. After participants sort these statements, they are given a post-sorting reflection activity where they detail why they sorted the statements the way they did as well as a provide any demographic and background information pertinent to the study. This will give us insight on if Title I programs are providing enough support for student success [10]. For example, for this study, participants will be asked to provide demographic information, details on the high school they graduated from, and questions relevant to EVT [4] (e.g., how much do you agree with the following statements [strongly disagree to strongly agree]: *I will earn an engineering degree*, *I will get and succeed in an engineering job post-graduation*).

Q-set Development

We first created our Q set by creating many statements that fit our student learning and resource availability criteria. Only a limited number of statements can be used in a Q set, so it is best to create more statements than it can hold to then iterate on and reduce to the final set. Statements were derived from personal experiences, prior studies [2], [3], [12], and existing literature. Morton drafted this initial pool.

These statements then underwent an iterative review process. Morton and Bork reviewed the statements jointly with the following goals: (1) aligning statements to the theoretical framework, (2) separating out double-barreled questions (separating questions that were asking on two things at once), and (3) filling out the statements to align with the intended scope. This resulted in statements being added, modified, and removed. After this was complete, the statements were reviewed by the Cultivate Lab group, consisting of the authors, two additional undergraduate electrical and computer engineering students, and one master's electrical and computer engineering student. They provided feedback on item clarity and scope. This feedback was taken into account by Morton before he met with Feyijimi. Jointly they worked to revise the statements. They then worked with Bork to jointly reduce the statements to the final draft set (detailed in preliminary findings).

Q-Sorting Technique for Data Collection
The Q-sorting process follows. This involves participants ranking the pre-defined set of statements (Q-set) based on their subjective experiences. These statements are arranged along a continuum from "most agree" to "most disagree," offering insight into their psychological significance [11]. Participants begin by categorizing statements into three broad groups: agree, disagree, and neutral. They subsequently rank these statements on a Q-grid ranging from -4 (strongly disagree) to +4 (strongly agree), detailed in Figure 1. For instance, while one student may rank "I am confident I can pursue an engineering career" at +4, another may rank it at -2, reflecting diverse viewpoints. This method makes participants think more about the options they are choosing rather than just a normal survey as they must compare statements to one another and fit them into the grid; that is, they can only strongly agree to 1 statement from the Q-set. The following sections will focus on the development of this Q-set.

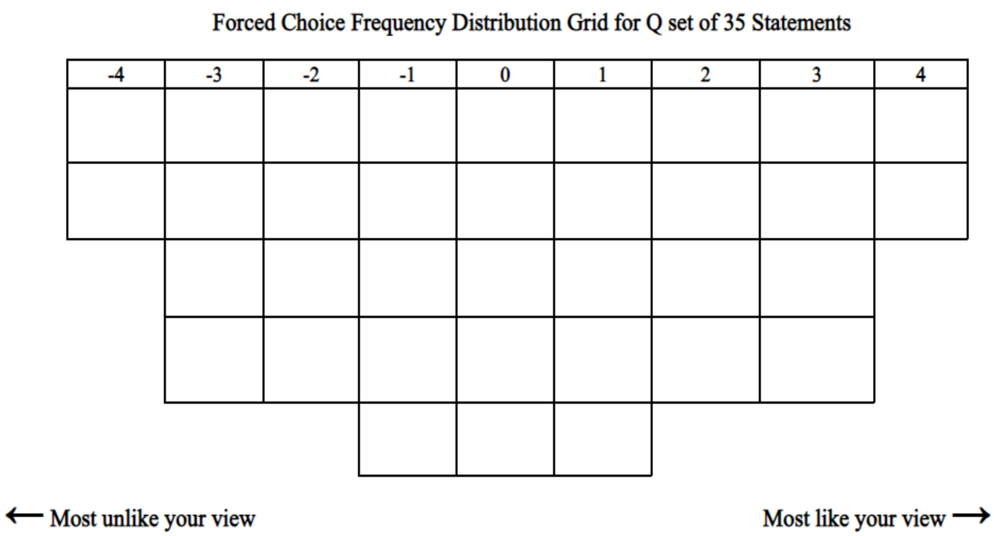

Figure 1. The Q sort distribution grid for data collection for the 35-item q-set.

Post-Sorting Reflections
After completing the Q-sort, participants will participate in a post-sorting activity. They will elaborate on their reasoning for ranking the statements as they did and provide demographic and background information relevant to the study, such as their high school type, personal aspirations, and agreement levels with Expectancy-Value Theory (EVT)-related prompts (e.g., *"I believe I will earn an engineering degree"*).

Rationale for Selecting this Method
Q methodology is a mixed-method approach designed to explore subjective viewpoints systematically [11]. It is particularly suitable for analyzing the perspectives of stakeholders in educational contexts, as it captures nuanced opinions while bridging qualitative and quantitative paradigms [11]. This study employs Q methodology to understand first-year students from Title I schools and their perspectives on pursuing engineering. By engaging participants in a structured

sorting process, the methodology facilitates a deeper exploration of their academic experiences [7], aligning with theoretical frameworks and research objectives.

Preliminary Findings - Generated Q-Set

The final Q set comprises 35 statements reflecting EVT categories and aligned with the research focus on Title I school students' engineering aspirations. Statements will be randomized for presentation to participants to ensure unbiased responses and foster authentic participant engagement.

Expectancies for Success

1. I think I can succeed in an engineering career
2. Guidance from school faculty (e.g., counselors, advisors, extracurriculars) has played a big role in my success.
3. I see a future career for myself in engineering
4. I feel like I can get a job in engineering
5. There are multiple engineering fields I could go into and succeed in
6. My teachers have been instrumental in shaping my learning.
7. My teachers played a crucial role in my collegial academic success.

Attainment Value

8. I was told that since I was good at math and science, and engineers are good at those, I would be a good engineer
9. I was uncertain about my chances of being accepted into college
10. I am confident that I can pursue an engineering career
11. my friends influenced my decision to pursue engineering as a career
12. I always knew that I wanted to be an engineer
13. I see myself as an engineer
14. I always knew I would go to college to become an engineer
15. I am confident that I am smart enough to succeed as an engineer
16. I have what it takes to be an engineer

Intrinsic Value

17. I was satisfied with the quality of education and resources at my high school.
18. I have many positive memories working with my friends on engineering related things
19. I am motivated to do engineering because it is a high-paying career
20. My mental health concerns had a significant impact to my pre-collegial academic performance
21. Solving engineering problems makes me feel happy
22. Engineering is not enjoyable as the concepts are too complex

Utility Value

23. I had access to engineering clubs at my high school to facilitate my learning experience
24. I had prior engineering experience to college
25. If I wanted to, I could participate in at least one internship through connections from my high school
26. My high school prepared me for the academic rigor of college courses

27. The extracurriculars offered at my high school prepared me for college

Cost

28. Before college, I was strongly introduced to engineering through my high school any extra curriculars outside of my school.
29. My teachers have been a good help to my learning and have played a role in my academic success
30. In my first semester of college, I learned more about engineering than I did at my high school
31. I lacked the resources to explore engineering careers at my high school
32. I had to reach out to outside sources from my school to succeed
33. Mental health made it harder to do well in school
34. Lack of money made it harder to do well in school
35. I feel external pressure to pursue an engineering degree

Future work

As discussed, the goal of this study is to examine first-year engineering students' perceptions of engineering. Specifically, we seek to compare the differences between students from low-income (Title I) and high-income schools. To do so, we will recruit at least 60 first-year engineering students, half from Title I schools and half from higher income area schools to complete the Q-sorting. Morton will first work with a subset of participants (2-4) to pilot the Q-set with via a think-aloud process. That is, he will ask participants to complete the Q-sorting and reflection process with him. This will allow for further validation of the Q-set. Once this is completed, full data collection will begin. These students will be asked to rank the statements generated and reflect on their rankings.

The students in the survey will be categorized into groups based on the high school that they went to (i.e., Title I and non-Title I schools). This will give us a baseline understanding of the effects of student learning in low-income and high-income high schools. We constructed the Q set to give statements that would show us the participants' experience with resource availability and success in their high school as these factors are crucial when transitioning into college [13]. Once the results are in, we will look for patterns and outliers to determine causes for Title I schools' lack of success.

Future data analysis will first focus on examining the responses from students from Title I schools and detailing significant findings (e.g., statements ranked high, statements consistently ranked neutral, etc.). We will then examine the post-reflection responses following an explanatory mixed methods analysis design (i.e., using qualitative data to expand upon quantitative findings). We will use best practices in qualitative data analysis to uncover trends or themes within the data, using both open-coding and guided coding leveraging EVT-STV. Once we have reviewed the data and trends for students from Title I schools, we will replicate these analyses in data samples with (1) students from high income schools and (2) all responses. These two groups will be used to compare against the findings from students from Title I schools to determine if any significant similarities or differences exist.

Conclusion: A Self-Reflection

Overall, Morton found this experience to be very helpful to my understanding of Title I and non-Title I students in engineering. EVT was a very useful structure in my methodology as Morton learned more about students' specific types of insecurities within the field of engineering. Creating the surveys with EVT added extra steps to the final product, but did not make it inherently more difficult to complete. In fact, this provided a resource to guide the re-wording of statements. There was a concern if there would be enough statements to vary to provide a rich analysis; at the same time, the EVT framework and prior work provided means to expand to the 35 statements. Morton hopes to be able to use this information for further research and to spread awareness of the situation for low-income students. Q methodology was a great way for the team to get a better understanding of how these students feel about engineering, and [TEAM] is excited to detail the findings. This work will continue to build on the similarities and differences between the two groups of students in this study.

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