Examining Student Learning and Motivation in a Summer Pre-Engineering Program: Implementing New Science and Engineering Standards (Fundamental)

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Abstract

The adoption of new science and engineering standards marks a statewide effort to make engineering thinking accessible to all students in Texas. These standards emphasize active inquiry and design-based learning, creating new opportunities to understand how such approaches influence student learning and motivation in informal pre-college settings. This quantitative study examines how the new science and engineering standards might influence student learning and motivation within a summer intensive pre-engineering program designed to foster early interest and confidence in science and engineering. The Dr. Manuel P. Berriozabal Prefreshman Engineering Program (PREP) typically supports more than 400 middle and high school students per year in a major Texas city. Throughout the five-week program, students, ages 11 to 17 years and enrolled in grades 7 through 12 from multiple surrounding local school districts, participate in an intensive academic experience. Anchored in a holistic educational model, the program combines rigorous academics with career exploration, cultural connection, and active engagement in pre-engineering learning experiences. Students engage in inquiry-based modules aligned to state science and engineering standards, integrating science and engineering concepts through authentic, hands-on applications. This research focuses on matched pre- and post-survey responses from over 400 participants across one summer season. This study addressed two primary research questions: (1) To what extent do students attribute changes in student motivation and interest in science, technology, engineering, and mathematics (STEM) content areas to their participation in the summer pre-engineering program? and (2) What early measures of student motivation, self-efficacy, and engagement during the summer pre-engineering program are associated with sustained interest and persistence in STEM pathways? The student study sample consisted of 49% Hispanic, 12% White non-Hispanic, and 40% from other racial/ethnic backgrounds. Pre- and post-program survey data was used in preliminary analyses. Initial findings indicate positive shifts in students' self-efficacy, understanding of engineering design, and motivation to pursue STEM coursework. Future work will include longitudinal tracking to assess sustained impacts on students' STEM identity, academic pathways, and career aspirations. Qualitative data will also be collected through student interviews and classroom observations to provide deeper insight into the learning experience. Findings will inform ongoing efforts to align pre-college engineering programs with evolving K-12 standards and contribute to a broader understanding of motivation and learning in informal STEM education.

Keywords: pre-college engineering education, motivation, informal learning, science and engineering standards, program evaluation, summer STEM programs

Introduction

In recent years, Texas has adopted updated Science and Engineering Practices (SEPs) within its state science standards. This has placed an increased emphasis on inquiry-based learning, problem-solving, and the application of STEM concepts to real-world contexts. The revisions reflect a broader national shift toward integrating engineering practices into K-12 education to support students' development of transferable skills such as critical thinking, collaboration, and innovation. Texas aims to better prepare students to engage with complex, authentic problems in academic and professional STEM settings. While SEPs are primarily designed for implementation within formal classroom environments, informal pre-college learning contexts, such as summer STEM and engineering programs, play a complementary and increasingly important role in supporting these practices. Informal programs often provide extended time, flexible structures, and hands-on experiences that enable students to engage more deeply with engineering design, data analysis, and collaborative problem-solving. Examining how state-aligned engineering practices are enacted in these settings is essential for understanding how standards-based learning extends beyond the classroom and influences student learning experiences more broadly.

Research in engineering and STEM education suggests that inquiry-based, standards-aligned learning experiences are associated with key student outcomes, including motivation, self-efficacy, identity development, and sustained engagement in STEM pathways [1], [2]. When students are positioned as active problem-solvers and contributors, they are more likely to develop confidence in their abilities, perceive STEM as relevant to their futures, and envision themselves in engineering-related roles. Prior research has documented gains in student confidence and interest following participation in summer pre-engineering and informal STEM programs, highlighting the potential of these experiences to support early persistence-related outcomes [3], [4]. Studies of informal engineering experiences further suggest that such engagements play a meaningful role in shaping students' developing engineering identities and their sense of belonging in STEM pathways [5]. Reviews of promising practices in STEM bridge and enrichment programs emphasize the importance of sustained, hands-on learning opportunities and intentional program design in supporting students' readiness and continued participation in STEM, particularly for those with limited prior exposure to engineering [1]. Related work examining integrated engineering design experiences across diverse educational contexts has similarly demonstrated positive associations with student engagement and career consideration [2]. These outcomes are particularly salient in pre-college contexts, where early experiences can influence longer-term academic and career trajectories.

To address this need, the present study examines pre- and post- changes in students' self-reported outcomes following participation in a summer pre-engineering program aligned with the state's SEPs. The study explores how engagement in standards-aligned, inquiry-based engineering experiences within an informal learning context is associated with changes in students' motivation, self-efficacy, identity, and engagement, as early indicators of persistence in engineering education pathways.

Program Description: Summer Pre-Engineering Program

The Pre-engineering program examined in this study is a 5-week intensive summer pre-engineering program designed to support middle and high school students' engagement with engineering concepts through inquiry-based, standards-aligned instruction. Students attend the program from diverse school districts, and the program is offered at multiple regional sites through partnerships with institutions of higher education (IHEs). The program's primary goal is to broaden participation in engineering by providing early, structured exposure to engineering practices, problem-solving, and STEM career pathways. The program follows a multi-level course sequence that allows students to participate across multiple summers, with each level building on prior experiences. Courses are designed to emphasize hands-on learning, collaboration, and real-world application of engineering concepts. Instruction is delivered by certified teachers and supported by undergraduate and graduate assistants with STEM backgrounds. Across all levels, curriculum materials are aligned with Texas science and engineering practices (SEPs), with particular focus on engineering design, data analysis, modeling, and communication. In each course students are administered a pre- and post-test to track and measure student progress from the start to the end of the course.

Alignment to Texas Science and Engineering Standards

Instructional modules within the program are intentionally aligned to Texas science and engineering standards, with a particular emphasis on science and engineering practices (SEPs) and concepts rather than isolated content outcomes. The engineering design standards in this study refer to the engineering components embedded within the Science Texas Essential Knowledge and Skills (TEKS), supplemented by the NGSS Engineering Design Framework as a conceptual guide when selecting and developing inquiry-based engineering modules. As shown in Table 1, PREP modules are intentionally designed to engage students in multiple scientific and engineering practices, particularly data analysis, modeling, and evidence-based reasoning. This alignment ensures that students are not only exposed to engineering concepts but actively engage in practices emphasized by the Science TEKS.

TABLE I. Alignment of PREP Modules to Science TEKS Scientific & Engineering Practices (SEPs)

PREP Module/ Learning Activity	Aligned Texas Science and Engineering Practices (SEPs)	Engineering Design Standards (NGSS)	Description of Alignment to Module/ Learning Activity
Engineering Design Challenges	**B.1(A)** Asking questions/defining problems; **B.1(B)** Applying SEPs to plan investigations; **B.2(D)** Evaluate experimental and engineering designs; **B.3(A)** develop evidence-based explanations	HS-ETS1-1 HS-ETS1-2 HS-ETS1-3	Students define a real-world water problem, establish criteria/constraints, design and test filtration systems, analyze performance data, and iteratively improve solutions.
Sphero Motion & Optimization Lab	**P.1(G)** developing and using models; **P.2(B)** analyze data by identifying significant statistical features; **P.2(C)** Using mathematical calculations to assess relationships in data; **P.3(A)** develops evidence-based explanations;	HS-ETS1-2 HS-ETS1-4	Students collect motion data using Sphero robots, model system behavior, and refine movement strategies using data-driven decision making.
Micro bit Sensor-Based Engineering Task	**I1.(D)** using tools & technology; **B.1(G)** Developing and using models to represent	HS-ETS1-3 HS-ETS1-4	Students program sensors to collect environmental data and refine system outputs

	systems; **B.3(B)** communicating explanations and solutions		through iterative testing and evaluation using digital tools. Solutions are then presented to peers.
Renewable energy systems Investigation	**C.1(B)** applying scientific practices to plan investigations; **C.2(B)** analyze data; **C.2(D)** evaluates experimental and engineering designs; **C.3(A)** constructing explanations	HS-ETS1-1 HS-ETS1-3	Students test renewable energy models, compare efficiency, and evaluate solutions based on constraints such as energy output and environmental impact.
Design Thinking & Prototyping	**E.1.(A)** Asking Questions/ defining problem; **E.1(F)** organizing data; **E.1(E)** collecting quantitative data; **E2.(A-D)** Analyze and interpret data to evaluate solutions; **E3.(B)** communicating explanations	HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4	Students engage in the full engineering design process to develop solutions to a self-selected community issue concluding in a presentation to stakeholders at a symposium.
Consensus building	**P.2(A)** identifies limitations of models; **P.3A** develop explanations supported by data; **P.3(C)** Engage in scientific argumentations using empirical evidence; **P.4(A)** analyzes, evaluate, and critique scientific explanations and solutions using empirical evidence	HS-ETSI-3 HS-ETS1-4	Students are guided in generating claims from their evidence. Groups come to consensus on their responses and defend their claims to other groups.

Students engage in activities that require defining engineering problems, developing and testing solutions, analyzing data, and iterating on design. These are all practices central to contemporary frameworks for K-12 engineering education [6], [7]. Research suggests that repeated engagement with engineering practices supports the development of transferable problem-solving skills and increases students' confidence in their ability to engage in engineering tasks, maintain motivation, and complete complex tasks [1], [2], [8]. Structured recurring engagement with engineering practices through pre-college engineering-designed curricula has demonstrated an increase in student engineering self-efficacy, and design thinking interventions have been shown to enhance students' creative self-efficacy and situational interest in STEM contexts [1].

Improvements in students' problem-solving skills, alongside increased confidence and teamwork outcomes, have been demonstrated following engagement in engineering design process activities and iterative design [8]. Central to student learning and the formation of understanding is the alignment of instructional experiences to science and engineering standards through sustained engagement with core SEPs and the assessment of student learning. Assessment of mastery of standards is most effectively achieved through performance-based and formative assessment approaches embedded in authentic engineering tasks. Research indicates that artifacts such as engineering notebooks, prototypes, data analysis, reflective documentation, and iterative solution testing provide valid evidence of students' developing proficiency in science and engineering practices by capturing how learners apply conceptual knowledge in context [1], [9].

These assessment methods allow educators to assess not only final solutions but also evaluate students' reasoning, iteration, and decision-making processes throughout the design process [10]. This research underscores the need for instructional models that integrate standards-aligned engineering practices with assessment strategies that capture meaningful evidence of student learning aligned with state science and engineering standards.

Culturally and Socially Responsive Design Elements

Frameworks for K-12 engineering education emphasize the importance of situating engineering learning within real-world contexts that are meaningful and relevant to students' lived experiences. In informal learning environments, contextualized engineering challenges grounded in community-based issues have been shown to increase student engagement, motivation, and perceptions of relevance [11], [12]. By framing engineering problems around authentic, locally relevant scenarios, students are more likely to view engineering as connected to their communities and everyday lives rather than as an abstract or inaccessible discipline. Critical for the development of STEM identity and sustained interest in engineering, especially among students from historically underrepresented backgrounds, are career exploration components that expose students to a broad range of STEM pathways and role models. Research also indicates opportunities to interact with or learn about individuals with diverse backgrounds working in STEM fields strengthen students' perceptions of engineering as attainable and socially relevant, thereby supporting motivation and persistence in STEM pathways [13] - [15]. By combining community-connected engineering challenges with intentional career exposure, students can gain a better understanding of the science and engineering standards and form meaningful connections. Culturally responsive program design plays a significant role in broadening participation in STEM and supporting students' motivation, identity development, and engagement in engineering learning.

Addressing Research Gaps and Research Questions

Although prior research has documented the benefits of inquiry-based and designed-centered engineering instruction supporting student motivation, self-efficacy, and STEM identity, several gaps remain within the PK-12 engineering education literature. The existing research has focused on the implementation of engineering practices within formal classroom settings, with comparatively limited empirical work examining informal and out-of-school engineering programs, despite their role as critical access points for early engineering experiences [10], [16]. There is a need for a more systematic investigation of how engineering standards and practices are enacted and experienced in informal contexts, where instructional structures, time frames, and assessment approaches differ from those of traditional classrooms [14]. Engineering education research studies center on curriculum design, instructional fidelity, and teacher practices, with an increasing emphasis on alignment with science and engineering standards. Few studies examine students' own perceptions of how engineering experiences influence their motivation, confidence, and interest in STEM [6], [10]. Research that explicitly captures student voice through self-reported measures is needed to better understand how learners attribute changes in motivation and STEM identity to participation in engineering programs, particularly in informal learning environments [13].

While few studies examine early indicators of persistence with pre-college engineering programs or provide models for identifying such indicators prior to long-term outcomes, motivation, self-efficacy, and engagement are widely recognized as predictors of persistence in STEM pathways [6], [13] - [15], [17]. Longitudinal research is frequently recommended, but there is a lack of scalable assessment models that allow programs to examine how early measures may be associated with sustained interest and continued participation in STEM over time [1]. This study addresses these gaps by presenting a standards-aligned, survey-based research-to-practice model situated within an informal summer pre-engineering program. By leveraging pre- and post-program survey data, curriculum grounded in Texas Science and Engineering Practices, and literature on STEM motivation and identity, this study emphasizes student-reported outcomes to examine how learners attribute changes in motivation and interest to program participation. Furthermore, by examining early measures of motivation, self-efficacy, and engagement associated with sustained interest in STEM pathways, the study contributes a practical framework for identifying early indicators of persistence that can inform program design, assessment strategies, and future longitudinal investigations in PK-12 education.

Data Collection and Analysis

This quantitative study used a pre- and post-survey design to examine changes in students' reported motivation, self-efficacy, engagement, and perceptions of STEM learning during participation in the summer pre-engineering program. The student study sample (n=402) consisted of 49% Hispanic, 12% White non-Hispanic, and 40% from other racial/ethnic backgrounds. Students were enrolled in grades 7 through 12, ranging in age from 11 to 17. This study uses matched pre- and post-survey data from 402 participants to examine changes in self-reported motivation, self-efficacy, engagement, and perceptions of STEM. Participants represented all five program levels and multiple years of prior program participation. This study utilized a pre-and post-survey instrument based on previous studies [18] - [20] and grounded in the framework of the Simpson-Troost Attitude Questionnaire (STAQ). The method utilized was self-reported responses from participants in the pre-engineering summer program using a five-point Likert scale ranging from strongly disagree to strongly agree.

The pre- and post-survey instruments were designed to measure constructs commonly associated with student engagement and persistence in STEM, including motivation, self-efficacy, collaborative learning, and interest in engineering careers as seen in Appendix A. Items related to problem-solving confidence, collaborative learning, and interest in STEM pathways align with established research indicating that self-efficacy and interest are strong predictors of students' continued participation in STEM coursework and careers [17], [1]. The post-program survey items also assessed students' perceived learning gains in science and engineering and their confidence in applying math and science to solve engineering problems. These constructs are consistent with prior studies examining affective and cognitive outcomes of engineering design-based learning experiences in informal settings [9], [10]. Items were explicitly aligned to engineering practices emphasized in the program. For example, students rated their confidence in solving problems, their ability to work effectively in teams, their enjoyment of design and engineering challenges, and their ability to use math and science to design solutions.

The pre-survey was administered on the STEM program's first day, before the commencement of any instructional activities, to ensure that initial responses reflected students' baseline attitudes and perceptions. Similarly, the post-survey was administered on the program's final day, after all activities were completed, to capture any changes in attitudes or self-efficacy resulting from participation. Both surveys were conducted electronically in a controlled, in-person environment, which allowed facilitators to provide clear instructions and address any questions from participants. Participants were given ample time to complete the surveys in a quiet, distraction-free setting, ensuring data consistency and minimizing response bias. Instructions emphasized the importance of honest and thoughtful responses. Qualtrics was the survey platform used to administer the age-appropriate surveys. Facilitators monitored the survey process and provided clarification when necessary. The datasets include pre-survey responses and post-survey responses.

A unique identifier was used to match pre- and post-survey data for each participant, ensuring consistency in the analysis. The pre-survey responses without a matching post-survey were excluded from further analysis. This matching process ensured that only participants with complete data sets were included in the final evaluation. After cleaning and matching, the final sample consisted of 402 participants. Among them 53% identified as male, and 47% identified as female. This refined dataset provided a reliable basis for assessing overall trends in student perceptions. SPSS software was used to analyze data. A pre- and post-survey median was determined for each survey item to observe construct-level trends. Ongoing analyses will include matched-sample comparisons and longitudinal tracking across program years.

Preliminary Findings

This study examined pre- and post-changes in students' self-reported outcomes following participation in the Dr. Manuel P. Berriozábal Prefreshman Engineering Program (PREP). The Wilcoxon signed-rank tests were conducted at the item level to examine statistically significant shifts in student responses, while construct-level medians were used descriptively to summarize overall trends [21]. Construct groupings were theoretically informed and used for descriptive interpretation; future analyses will examine construct validity using factor-analytic methods.

RQ1: To what extent do students attribute changes in motivation and interest in STEM to program participation?

Results indicate statistically significant pre-post gains in items aligned with engineering interest and value, including increased motivation to continue developing STEM skills and greater career awareness of engineering careers. These findings suggest that program participation is associated with strengthened interest in engineering and increased recognition of the relevance of STEM learning to students' future goals.

RQ2: What early measures of motivation, self-efficacy, and engagement may serve as indicators associated with sustained interest and future persistence in STEM pathways?

Items aligned with engineering self-efficacy, engineering identity and belonging, and behavioral and cognitive engagement in engineering practices also indicated a statistically significant gain. Improvements in self-efficacy reflect increased confidence in students' ability to solve problems and succeed in engineering-related tasks, while gains in identity-related items indicate early movement toward seeing oneself in future engineering roles. Additionally, increased engagement in engineering practices suggests greater participation and involvement in learning activities, which are early indicators commonly associated with persistence pathways.

Tables II and III summarize item-level pre- and post- results aligned with Research Questions 1 and 2, respectively, using Wilcoxon signed-ranked tests and descriptive median trends to support interpretation of changes related to motivation, self-efficacy, identity, and engagement. Effect sizes will be reported in future analyses. Preliminary inspection suggests small-to-moderate effects across items.

TABLE II. Item-Level Results Addressing RQ1: Changes in Motivation and Interest

Construct	Item	N	Wilcoxon *p*-value	Pre-Median	Post-Median	Interpretation
Engineering Interest & Value	Q6	398	0.0031	5	5	Positive distributional shift (ceiling effect)
Engineering Interest & Value	Q18	400	0.0064	4	5	Increased awareness of engineering pathways
RQ1 Summary	-	-	-	4.5	5	Overall increase in motivation and value

Note: Wilcoxon signed-rank tests were conducted at the item level using paired pre- and post-survey responses. Medians are reported descriptively. A stable median with a statistically significant p-value indicates a positive shift within the response distribution. Ceiling effects likely reflect prior program exposure and high baseline interest among returning participants.

TABLE III. Item-Level Results Addressing RQ2: Early Indicators Associated with Persistence in STEM Pathways

Construct	Item	N	Wilcoxon *p*-value	Pre-Median	Post-Median	Interpretation
Engineering Self-Efficacy	Q1	401	0.0004	4	5	Increased confidence in engineering skills
Engineering Self-Efficacy	Q14	401	0.0290	4	5	Stronger belief in ability to succeed
Engineering Identity & Belonging	Q8	401	0.00001	3	4	Improved future engineering self-concept
Engineering & Belonging	Q19	399	0.0095	4	5	Increased participation orientation
Behavioral & Cognitive Engagement	Q9	402	0.0263	4	5	Increased engagement in engineering practices
RQ2 Summary	-	-	-	3.8	4.8	Broad gains across persistence-related indicators

Note: Inferential analyses were conducted at the item level to avoid over-aggregation. Construct-level medians summarize overall directional trends and were not subjected to inferential testing.

Across constructs, statistically significant item-level changes were observed even when medians remained stable, as shown in Appendix B, indicating distributional shifts consistent with ceiling effects. Collectively, these preliminary findings suggest that participation in the summer pre-engineering program is associated with positive changes in multiple earlier indicators of engagement, identity development, and persistence in engineering pathways.

Discussion and Conclusions

This study contributes to the engineering education literature by examining short-term changes in students' self-reported outcomes following participation in PREP. Rather than making claims about causal impact, the discussion focuses on how observed pre- and post-data patterns across constructs may inform understanding of early mechanisms associated with persistence in engineering pathways. The findings suggest that structured, immersive pre-college engineering experiences may support early interest across multiple dimensions, including students' confidence in their engineering-related abilities, motivation, and perceived value of engineering, the development of a sense of identity and belonging, and engagement in engineering practices. The co-occurrence of gains across these construct-aligned item groupings is consistent with prior work emphasizing that persistence is shaped not by a single factor, but by the interaction of beliefs, motivations, and learning behaviors over time.

In relation to RQ1, which explored the extent to which students attribute changes in motivation and interest in STEM to program participation, results indicate statistically significant increases in students' interest in engineering, enjoyment of design challenges, and interest in pursuing STEM careers. The inclusion of real-world engineering challenges and structured career exploration opportunities appears to have contributed to students' increased awareness of and interest in STEM pathways, supporting claims that exposure to applied engineering contexts and diverse role models can strengthen STEM identity and career aspirations. RQ2 examined early measures aligned with constructs associated with sustained interest and persistence in STEM pathways. Results demonstrate significant gains in self-efficacy, problem-solving confidence, and collaborative engagement. Students reported increased confidence in solving problems, working in teams, and applying math and science to engineering tasks. These outcomes align with constructs commonly associated with long-term persistence in STEM pathways.

The results demonstrate how standards-aligned engineering practices can be effectively implemented in informal learning environments, not just formal classroom settings. From a programmatic perspective, these results underscore the potential value of intentionally designing learning environments that simultaneously address skill development, relevance, and participation in authentic engineering activities. An important methodological insight emerging from this analysis is the presence of statistically distributional shifts even when median values remain unchanged. For a study with a heterogeneous participant population, this pattern highlights the importance of using analytic approaches that capture changes beyond simple central tendency measures. In this context, item-level nonparametric testing combined with construct-level descriptive summaries provides a transparent and appropriate strategy for examining early change without overstating construct-level effects.

Several limitations should be acknowledged. First, the findings rely on self-reported survey data collected immediately following program participation and therefore reflect short-term outcomes rather than sustained changes. Furthermore, some post-items used retrospective comparative phrasing, which may introduce response-shift bias. Second, inferential analyses were conducted at the item level, and construct-level trends were used descriptively rather than as validated composite measures, which limits claims about construct-level statistical significance. Third, the absence of a comparison group constrains causal interpretation. These limitations are consistent with the scope of this study and inform directions for continued investigation. Future work will extend the analysis by examining multiple cohorts, exploring longitudinal relationships between subsequent persistence-related outcomes and course academic performance, and refining construct-level measures by aligning with an engineering learning framework. As this research develops, it has the potential to contribute both methodological guidance for evaluating pre-college engineering programs and empirical insights into how early learning experiences support students' evolving pathways into engineering education.

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Appendix A

Pre- and Post- Survey Instruments

Pre-Survey	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
1.I am confident I can solve problems when things don't go as planned.	o	o	o	o	o
2.I work well in teams with other students.	o	o	o	o	o
3.I enjoy using creativity to solve problems.	o	o	o	o	o
4.I can give helpful feedback to my classmates.	o	o	o	o	o
5.I am good at problem solving.	o	o	o	o	o
6.I want to keep developing my STEM abilities.	o	o	o	o	o
7.I see myself in a STEM career in the future.	o	o	o	o	o
8.I know where to find information about STEM careers.	o	o	o	o	o
9.I am curious about how things work (machines, electronics, etc.).	o	o	o	o	o
10.I enjoy design or engineering challenges.	o	o	o	o	o
11.I want a future job where I use science or engineering.	o	o	o	o	o
12.I am good at math.	o	o	o	o	o
13.I am good at science.	o	o	o	o	o
14.I believe anyone can become an engineer.	o	o	o	o	o
15.I believe I can be successful in my STEM career.	o	o	o	o	o
16.I can use math and science together to invent useful things.	o	o	o	o	o
17.My family believes I am good at STEM activities.	o	o	o	o	o
18.I know someone who works in a STEM career.	o	o	o	o	o
19.I have participated in STEM programs outside of school.	o	o	o	o	o

Post-Survey	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
1.I am more confident I can solve problems when things don't go as planned.	o	o	o	o	o
2.I work better in teams now than before the program.	o	o	o	o	o
3.I enjoy using creativity to solve problems.	o	o	o	o	o
4.I can give helpful feedback to my classmates.	o	o	o	o	o
5.I am good at problem solving.	o	o	o	o	o
6.I want to keep developing my STEM abilities.	o	o	o	o	o
7.I see myself in a STEM career in the future.	o	o	o	o	o
8.I know where to find information about STEM careers.	o	o	o	o	o
9.I am curious about how things work (machines, electronics, etc.).	o	o	o	o	o
10.I enjoy design or engineering challenges.	o	o	o	o	o
11.I am more interested in having a career in science or engineering.	o	o	o	o	o
12.I am good at math.	o	o	o	o	o
13.I am good at science.	o	o	o	o	o
14.I believe anyone can become an engineer.	o	o	o	o	o
15.I believe I can be successful in my STEM career.	o	o	o	o	o
16.I can use math and science together to invent useful things.	o	o	o	o	o
17.My family believes I am good at STEM activities.	o	o	o	o	o
18.I know someone who works in a STEM career.	o	o	o	o	o
19.I have participated in STEM programs outside of school.	o	o	o	o	o
20.I learned more about science this summer.	o	o	o	o	o
21.I learned more about engineering this summer.	o	o	o	o	o
22.I like science more now than I did at the start of the program.	o	o	o	o	o

23.I like engineering more now than I did at the start of the program.	o	o	o	o	o
24.I am more confident that I can learn science.	o	o	o	o	o
25.I am more confident that I can learn engineering.	o	o	o	o	o
26.I can use data to solve a science or engineering problem.	o	o	o	o	o

Appendix B

TABLE IV.

Item-Level Pre- and Post Changes Organized by Constructs

Construct	**Item**	**N**	**Wilcoxon *p***	**Pre Median**	**Post Median**	**Trend**
Engineering Self-Efficacy	Q1	401	0.000372	4	5	↑
	Q14	401	0.029021	4	5	↑
	Construct Median	-	-	4	5	↑
Engineering Interest & Value	Q6	398	0.003091	5	5	↑*
	Q18	400	0.006405	4	5	↑
	Construct Median	-	-	4.5	5	↑
Engineering Identity & Belonging	Q8	401	0.000011	3	4	↑
	Q19	399	0.009532	4	5	↑
	Construct Median	-	-	3.5	4.5	↑
Behavioral & Cognitive Engagement	Q9	402	0.026265	4	5	↑
	Construct Median	-	-	4	5	↑

Note: Wilcoxon signed-rank tests were conducted at the item level using paired pre- and post-survey responses. Construct-level medians are reported for descriptive purposes only to summarize overall trends and are not subjected to inferential testing. *A constant median with a significant Wilcoxon result indicates a positive distributional shift (ceiling effect).