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Pilot Study: From Curiosity to Career- The Influence of a Summer Camp on High School Students' Interest in Transportation and STEM Careers

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Pilot Study: From Curiosity to Career- The Influence of a Summer Camp on High School Students' Interest in Transportation and STEM Careers

Abstract

This study evaluates the impact of a summer camp designed to increase high school students' interest in transportation and related STEM fields. The camp, which spanned one and half weeks, included a variety of activities such as hands-on workshops, field trips to transportation hubs like airports and traffic management centers, and discussions with professionals from transportation, engineering, and environmental science sectors. Pre- and post-survey data were collected from high-school students to assess changes in their knowledge and career interests. Results demonstrate a significant shift in student engagement with transportation fields. After attending the camp, 65% of students reported an increased interest in transportation technologies, with 45% stating they gained greater familiarity with transportation systems and concepts, compared to their pre-camp levels. Moreover, 40% of students indicated they were now more likely to consider a career in transportation, with specific interest in careers such as civil engineering, urban planning, and traffic management. The camp also fostered increased enthusiasm for other STEM fields. 55% of participants reported heightened interest in engineering, while 35% expressed increased curiosity about environmental science. The camp's combination of interactive learning sessions, exposure to real-world transportation challenges, and direct engagement with industry experts played a key role in these outcomes. Furthermore, the program positively influenced career exploration, with 30% of students considering roles in civil engineering, 25% in robotics, and 20% in construction management as a result of their camp experience. The field trips and hands-on activities, such as building basic circuits and observing traffic systems in action, were cited by participants as the most valuable components of the camp. These findings suggest that experiential learning, coupled with industry exposure, can significantly enhance students' awareness and interest in STEM careers, particularly in transportation and related sectors.

Keywords: Transportation, STEM Education, Civil Engineering, Career Trajectories, Summer Camp

Introduction

The growing demand for a diverse and skilled workforce in transportation and STEM fields necessitates innovative approaches to inspire and educate the next generation. Transportation engineering, which encompasses areas like civil engineering, urban planning, traffic management, and environmental sustainability, is pivotal to addressing the challenges of modern infrastructure development. However, these fields face a persistent talent gap, particularly among underrepresented groups. Addressing this issue requires targeted educational interventions that combine theoretical learning with practical exposure to career opportunities [1].

Summer camps have proven to be effective platforms for engaging students in STEM disciplines, offering hands-on learning experiences and fostering early interest in technical fields [2]. This study evaluates the outcomes of a one-and-a-half-week summer camp designed to spark curiosity

and encourage career aspirations in transportation and STEM-related domains. Through pre- and post-surveys, the program assessed shifts in students' engagement, interest, and career aspirations with particular emphasis on transportation technologies and construction engineering concepts. Despite the growing emphasis on STEM education, fewer initiatives focus on transportation and construction-specific career pathways [3]. Integrating these fields into summer programs for middle and high-school students not only piques their engagement in these areas but also addresses workforce gaps while fostering interdisciplinary skills. The results of this research aim to contribute to a broader understanding of how experiential learning can influence career trajectories in these STEM fields.

Background and Literature Review

Transportation and STEM Education: Transportation engineering is at the core of modern infrastructure development, bridging disciplines like civil engineering, environmental science, and urban planning. As global urbanization accelerates, the need for innovative transportation solutions becomes increasingly critical. Research highlights the value of early exposure to these topics in shaping students' academic interests and career aspirations. According to the National Science Board, students introduced to engineering and environmental science concepts during high school are significantly more likely to pursue STEM degrees [4]. Hands-on and experiential learning approaches have been shown to enhance student engagement in technical fields [2]. Kolb's experiential learning theory emphasizes the importance of connecting theory with practice through activities that involve concrete experience, reflective observation, abstract conceptualization, and active experimentation [5]. Summer camps, in particular, serve as effective platforms for this model, as they provide immersive environments that blend structured learning with real-world applications. Studies by Yilmaz et al. and Hammack et al. have demonstrated that STEM-focused camps foster a lasting interest in engineering and related fields, especially when activities include field trips, direct industry engagement, and project-based learning [6-7].

Construction Engineering in STEM Outreach: The integration of construction engineering concepts into STEM outreach programs can provide students with a clearer understanding of the design and implementation of infrastructure projects. Construction engineering involves planning, designing, and managing building systems, making it a vital component of transportation systems and urban development. Despite its importance, construction engineering topics are often underrepresented in pre-college STEM initiatives [8]. Introducing students to concepts like material selection, structural design, and project management through interactive workshops and site visits can demystify these fields and inspire career exploration.

The National Academy of Engineering emphasizes the importance of introducing construction engineering concepts to students early in their educational journeys [9]. Programs that incorporate real-world construction challenges, such as designing roadways, understanding material properties, and simulating traffic flows, enable students to appreciate the interdisciplinary nature of infrastructure development. Furthermore, exposure to construction engineering aligns with broader efforts to address workforce shortages in critical infrastructure-related fields. Construction engineering's relevance extends beyond technical skills; it also emphasizes teamwork, project planning, and communication. By incorporating these elements into STEM education and outreach, educators can prepare students for the multifaceted demands of engineering careers.

Gaps in STEM Education for Transportation and Construction: While there is a growing emphasis on STEM education, targeted programs focusing on transportation and construction engineering remain limited. A 2020 report by the American Society of Civil Engineers (ASCE) highlights that many high school STEM programs emphasize general science and technology concepts but lack depth in applied engineering and infrastructure topics [10]. This gap underscores the need for specialized outreach initiatives that introduce students to transportation systems, sustainable construction practices, and the societal impact of engineering solutions. Research also indicates that engaging students in interdisciplinary projects—combining elements of transportation, robotics, and environmental science—can increase their interest and confidence in pursuing technical careers. Hammack et al. and other researchers found that students participating in construction-related workshops reported higher levels of understanding and interest in civil engineering compared to peers engaged in general STEM activities [11-13]. By integrating construction engineering concepts into transportation-focused programs, educators can create a more comprehensive and impactful learning experience.

Methodology

Program Design and Objectives: The summer camp was designed as a one-and-a-half-week immersive experience to introduce high school students to transportation and related STEM fields. The primary objectives were to:

1. Increase student awareness and interest in transportation systems, technologies, and careers.
2. Introduce key construction engineering concepts, including material selection, structural analysis, and project management.
3. Provide hands-on learning opportunities to bridge the gap between theoretical knowledge and real-world applications.
4. Foster connections between students and professionals in transportation, engineering, and environmental science.

Recruitment and Participants: The program targeted students from diverse backgrounds, particularly those from underrepresented groups in STEM. Recruitment strategies included partnerships with local schools, community organizations, and outreach events. A total of 16 students registered, with 14 completing the program, however three did not fill out the survey. The participant demographics included representation from multiple high-school grade levels.

The minimum criteria for acceptance for the camp was as follows:

- Students must be in the 9th through rising 12th grade.
- Students must have successfully completed pre-algebra or be qualified for enrollment in pre-algebra for the upcoming school term.
- Students must have a cumulative grade point average of 2.5 or higher.
- Students must demonstrate an expressed interest in engineering, science, and transportation technology as illustrated in an essay written by the student.

Curriculum and Activities: The curriculum combined lectures, interactive workshops, field trips, and hands-on projects to create a comprehensive learning experience. Key activities included:

- *Introduction to Transportation Systems*: Lectures on traffic management, urban planning, and sustainable transportation practices.
- *Construction Engineering Workshops*: Hands-on sessions on material properties, structural design, and roadway construction techniques.
- *Field Trips*: Visits to transportation hubs, including an airport, a traffic management center, and a construction site, where students observed real-world applications of engineering concepts.
- *Industry Engagement*: Discussions with professionals in civil engineering, robotics, and environmental science, offering insights into career pathways and industry challenges.
- *Project-Based Learning*: Group projects focused on designing traffic systems, building basic circuits for transportation technologies, and simulating sustainable construction practices.

Data Collection Tools and Techniques

The program's impact was assessed using a mixed-methods approach:

1. *Pre- and Post-Surveys***:** Administered at the beginning and end of the camp to measure changes in student knowledge, interest, and career aspirations.
2. *Daily Reflections***:** Students provided feedback on activities through written reflections and group discussions.
3. *Observation and Notes***:** Instructors documented engagement levels, interactions, and challenges during activities.

Data Analysis

Quantitative data from the surveys were analyzed using descriptive statistics to identify trends and shifts in student interest and understanding. Qualitative feedback from reflections and observations was thematically analyzed to provide context and identify areas for improvement. This dual approach ensured a comprehensive evaluation of the program's outcomes. In addition to assessing individual components of the camp, the analysis also explored correlations between specific activities (e.g., field trips, workshops) and changes in student perceptions. This helped to identify the most impactful elements of the program.

Results and Discussion

The results of the summer camp were measured through pre- and post-camp surveys, observational data, and feedback collected from participants. This section presents the findings related to participant engagement, shifts in knowledge and interest, and qualitative feedback on the program's impact.

1. Shift in Career Interest in Transportation Pre- and Post- Camp: Figure 1 illustrates the shift in students' likelihood of considering a career in transportation before and after attending the summer camp.

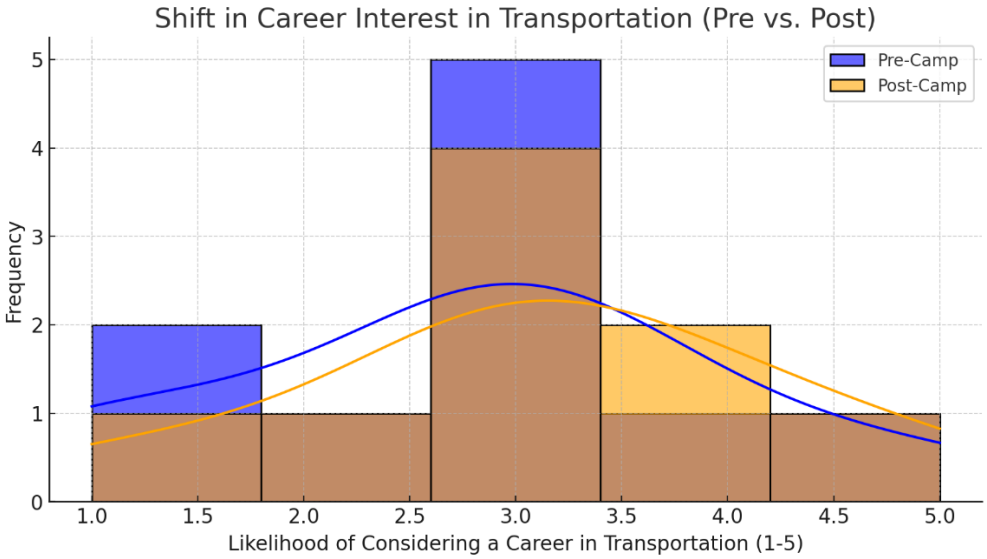

Figure 1. Shift in Career Interest in Transportation (Pre vs. Post)

The blue bars represent pre-camp responses, while the orange bars represent post-camp responses. The key takeaways are:

1. *Increase in Career Interest Post-Camp*: The orange distribution (post-camp) shows a noticeable shift towards higher values (4 and 5). This indicates that more students reported a higher likelihood of pursuing a career in transportation after the camp experience.
2. *Reduction in Low-Interest Responses*: The lower ratings (1 and 2) have decreased significantly in the post-camp responses, suggesting that the program effectively reduced initial disinterest or uncertainty about transportation careers.
3. *Broadening of High Engagement*: A higher concentration of students rated their interest at 4 and 5 post-camp compared to pre-camp. This suggests that hands-on activities, industry exposure, and mentorship had a positive impact on student perceptions of transportation careers.

2. Pre- and Post- Camp Word Cloud Analysis: Figures 2 and 3 illustrate the word clouds that were submitted by participants on Day 1, before starting the camp and on Day 8, on the last day of camp. The word clouds visualize the key themes in students' responses to "What do you hope to gain from attending this summer camp?" (Pre-Camp) and "What did you gain from attending this summer camp?" (Post-Camp). These word clouds are part of qualitative data collected to study participant engagement and their learnings. Figure 2 depicts the responses of the participants about their expected gains from this summer camp and figure 3 reflects their responses for actual gains from this summer camp.

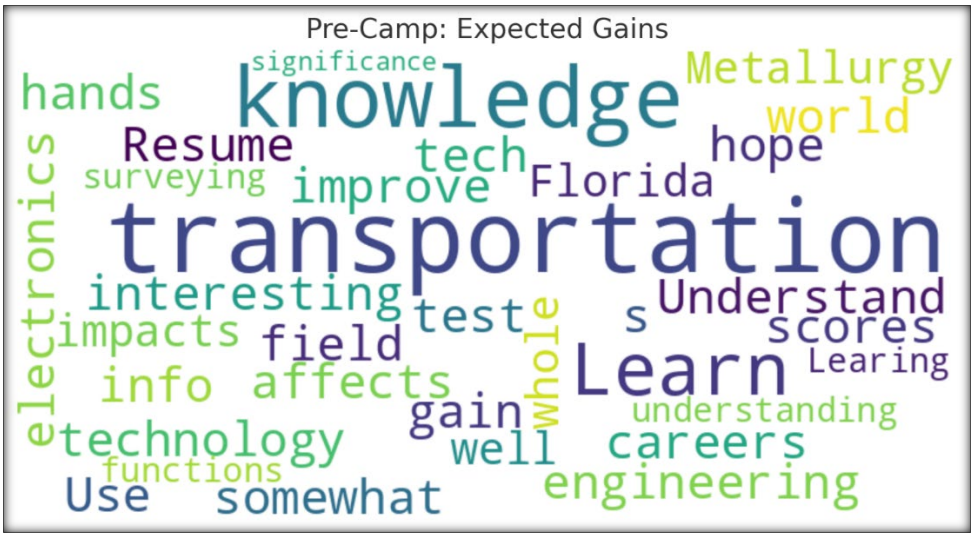

Figure 2. Pre-Camp: Expected Gains

Figure 3. Post-Camp: Actual Gains

Some of the key observations of these Word Clouds of Pre-Camp vs. Post-Camp responses are:

Pre-Camp Word Cloud (Expected Gains)

- The most prominent words include "learn," "engineering," "transportation," "technology," and "experience."
- This suggests that students entered the camp with a general curiosity about STEM, expecting exposure to engineering and transportation fields.
- Many students also mentioned specific interests such as civil engineering, robotics, and urban planning, indicating their pre-existing STEM interests.

- Terms like "career" and "knowledge" suggest that students were seeking career guidance and technical knowledge.

Post-Camp Word Cloud (Actual Gains)

- The most frequently mentioned words shifted towards practical experiences, including "hands-on," "projects," "field trips," and "real-world applications."
- This suggests that students found experiential learning to be one of the most impactful aspects of the camp.
- Terms like "confidence," "future," and "interest" indicate that students gained more clarity and motivation regarding career choices.
- The emergence of "construction," "management," and "civil engineering" in the post-camp responses shows that the camp effectively introduced students to the practical aspects of transportation and construction fields.

3. Pre- and Post- Camp Sentiment Analysis: Figure 4 depicts the results for sentiment analysis showing how the responses vary for pre and post-survey data.

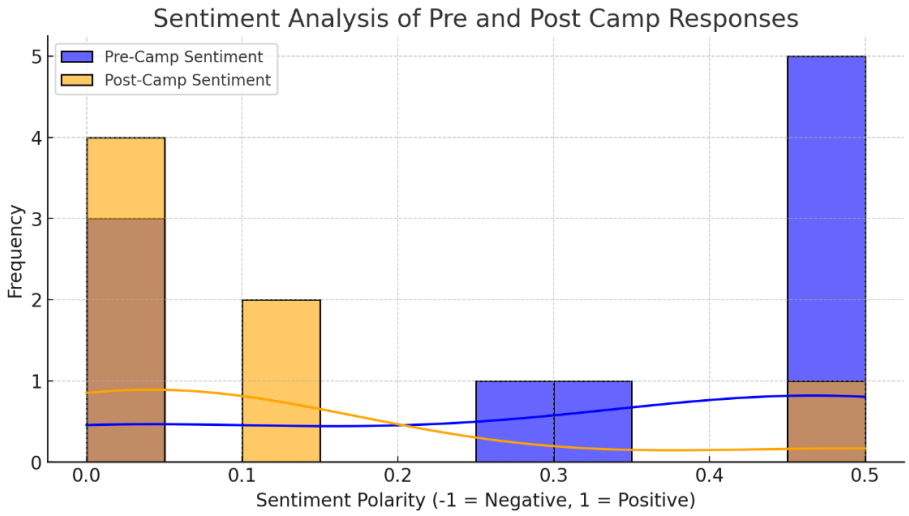

Figure 4. Pre- and Post- Camp Sentiment Analysis

Pre-Camp Sentiment: The mean sentiment score was lower, indicating that students had neutral to slightly positive expectations about the camp. The standard deviation was higher, suggesting more variation in student expectations- some were excited, while others were uncertain.

Post-Camp Sentiment: The mean sentiment score increased, showing that students had a more positive outlook after the camp. The standard deviation was lower, meaning that students' experiences became more consistently positive. The distribution shift in sentiment (visualized in the histogram) confirms that students left the camp feeling more engaged and motivated.

It is also worth noting that sentiment scores ranged only from 0 to 0.5, as students were responding to positively framed prompts and expressed largely constructive or enthusiastic reflections, resulting in responses that were neutral to moderately positive, with no strongly negative sentiment detected.

4. Correlation Between Pre- and Post- Camp Survey Reponses: Figure 5 presents the correlation between pre- and post-camp responses across different areas of student interest and confidence in transportation-related careers. Higher correlation values indicate that students retained or strengthened their initial interests, while lower or negative correlations suggest a shift in perceptions after the camp.

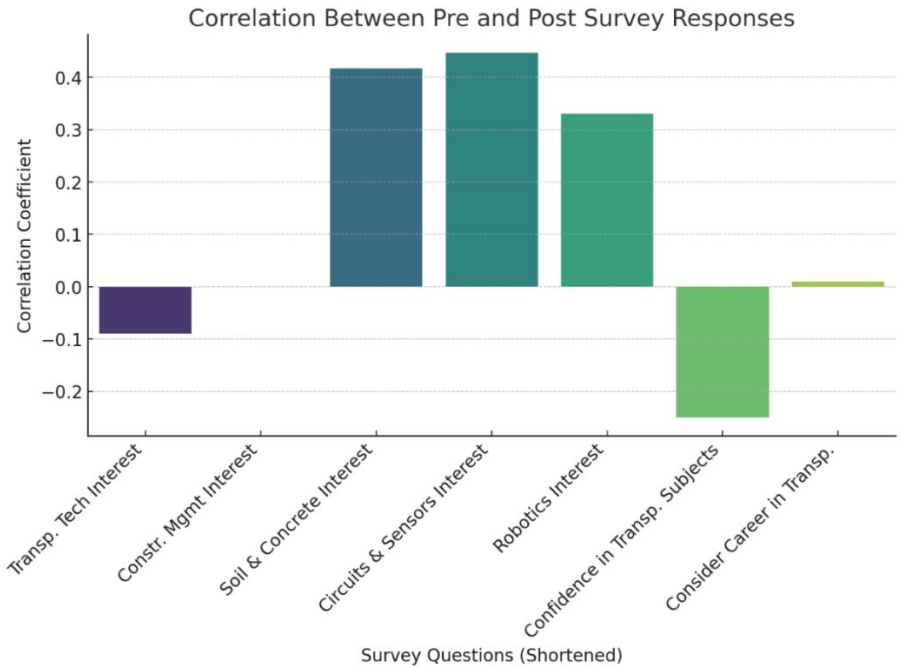

Figure 5. Correlation Between Pre- and Post-Survey Responses

Some key takeaways of the correlational analyses depict how participants' interest varied in areas they were introduced at the camp are as follows:

a) Strong Positive Correlations (Above 0.3)
   - Soil & Concrete Interest (~0.45) and Circuits & Sensors Interest (~0.43)
     - Students who were already interested in these subjects before the camp retained or strengthened their interest post-camp.
     - This suggests that hands-on activities in these areas (e.g., material testing, circuit-building, and surveying) effectively reinforced student engagement.
   - Robotics Interest (~0.35)
     - A significant correlation suggests that students maintained their initial enthusiasm for robotics.
     - Exposure to robotic arms (Dobot), programming, and sensor applications likely contributed to sustaining this interest.

b) Moderate to Weak Correlations (~0.0 to 0.2)
    - Consideration of a Career in Transportation (~0.02)
        - This near-zero correlation suggests that some students changed their career interest significantly after attending the camp.
        - While some became more motivated to pursue transportation careers, others may have discovered new interests in engineering, robotics, or construction.
    - Transportation Technology Interest (~0.0)
        - This result may indicate a shift in student perception—perhaps students entered the camp thinking transportation technology was one thing, but learned it was broader or more complex than expected.
c) Negative Correlation: Confidence in Transportation Subjects (~ -0.25)
    - This negative correlation suggests that some students became more self-aware of their knowledge gaps after exposure to real-world transportation engineering concepts.
    - While they gained valuable insights, some may have realized the depth and complexity of the field, which could have lowered their confidence in their ability to succeed in these subjects.

Conclusions

The summer camp successfully increased student interest in transportation and construction related careers, reinforcing the value of experiential learning, field trips, and interactive STEM activities. These findings highlight the importance of such initiatives in inspiring the next generation of STEM professionals in these areas. Career-focused responses increased post-camp, demonstrating that the program enhanced career awareness in transportation and construction. While The camp was effective in strengthening students' interests in hands-on topics like soil mechanics, sensors, and robotics, transportation-related career interest showed mixed results, indicating that students reevaluated their career choices based on their experiences. The slight decline in confidence in transportation subjects suggests that while students gained exposure, they also realized that these fields require further study and skills development.

For the word clouds, the shift of responses from abstract expectations (learning and exposure) to practical experiences (hands-on projects and career clarity) highlights the effectiveness of experiential learning. Also, the increased mention of career-related terms in the post-camp responses suggests that the camp successfully influenced students' perceptions of STEM and transportation careers. The word clouds reinforce the idea that engagement with real-world projects and industry professionals had a lasting impact on students' interest and career aspirations. The mixed career interest outcome suggests an opportunity for researchers to further highlight real-world career pathways in transportation engineering, planning, and construction management. Additional data analysis on qualitative responses could further explain why some students gained or lost confidence in transportation-related topics.

Acknowledgements

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