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Engaging High School Students in a DOT-Funded Summer Camp to Promote Transportation Engineering Majors and Careers

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Abstract

Nowadays, the transportation industry faces significant workforce development challenges, including an aging workforce, demographic shifts, rapid technology advancement, and a lack of interest from younger generations. As a result, the need for workforce development programs related to transportation is at an all-time high. To tackle current issues in technology, environmental sustainability, and human resources, a holistic approach is essential – beginning with early student engagement and education before college. K-12 outreach programs led by universities are designed to introduce students to various fields and career options. Nevertheless, there is a lack of comprehensive discussion and documentation on their benefits and results, particularly in transportation engineering. This paper presents a DOT-funded summer camp hosted by a university aimed at increasing the number and diversity of students pursuing higher education and careers in transportation-related fields. The camp curriculum comprised lectures by senior transportation professionals, student-led projects, field trips, evening activities, and mentorship opportunities. The program's success was assessed through mandatory pre- and post-student learning outcomes surveys and a voluntary feedback survey. Results from the learning outcomes surveys showed a substantial increase in students' understanding of targeted learning areas, with those able to explain key concepts rising from 24% to 78%, while those unable to explain decreased from 26% to 1%. The voluntary feedback survey indicated that all 17 respondents (out of 25 participating high school students) were satisfied with the camp, as evidenced by their satisfaction levels, ratings of activities, and the likelihood of recommending this camp to peers. This paper aims to guide engineering educators in developing a skilled and diverse workforce for transportation.

Introduction

Transportation is essential for moving people and goods, making transportation systems a key factor in economic growth. The effectiveness of these systems relies on advanced technology and a knowledgeable, well-trained workforce. The importance of preparing and training the workforce integral to an efficient transportation system was highlighted by the Transportation Research Board (TRB) [1]. Their 2003 report specifically identified University Transportation Centers as valuable resources for ongoing workforce training. They warned about the risks of inaction, indicating that insufficient training could lead to poor agency performance, wasteful resource use, and increased costs to accommodate future needs. Furthermore, they emphasized the need for strategic workforce planning rather than simply filling job vacancies, especially in a competitive employment market. Fast forward to today, the urgency for workforce development in transportation has reached unprecedented levels. Resources available for modernizing and managing transportation systems are dwindling, while demographic shifts, rising mobility demands, and environmental challenges require significant investments in technology and infrastructure. The transportation workforce must be prepared to tackle these urgent issues, leading to a need for training and education that aligns with the changing environment. As a result, the demand for programs focused on transportation workforce development has never been higher.

In addition, the ongoing issue of insufficient diversity in Transportation Engineering, or the overall science, technology, engineering, and math (STEM) fields, raises concerns regarding both social equity and maintaining a competitive workforce on a global scale [2]. To remain competitive internationally, educators need to boost the overall participation, retention, and representation of individuals from diverse backgrounds in STEM disciplines [2]. The enrollment and retention of underrepresented students in STEM fields at the collegiate level are crucial for achieving diversification in these areas and workforce development [3]. To tackle all the challenges mentioned above, which are related to technology, environmental sustainability, and human resources, a well-rounded approach is essential, beginning with the education and exposure of pre-college students [4].

Students' understanding of a profession affects their choice to pursue it. For instance, Wyss et al. (2012) found that watching recorded video interviews with STEM professionals positively influenced middle school students' interest in STEM careers [5]. Furthermore, students start making career decisions as early as middle school, so it is crucial to provide information about STEM careers before and during these years [5]. In a recent study, high school and college students indicated that the most significant factor impacting their career decision was a personal interest in the field, which largely stemmed from teachers' STEM knowledge and parental influence regarding their careers [6]. Additionally, Maltese and Tai (2010) noted that nearly 40% of professionals in science and graduate students attributed their interest in the field to factors related to school [7]. In other words, their experience of studying STEM knowledge during school plays a crucial role in shaping students' perceptions of STEM. According to Social Cognitive Career Theory, individuals make career choices partly based on their interests, attitudes, and values [8]. Moreover, interest in STEM fields has been connected to students' awareness of STEM career options [9]. The shortage of students enrolling in engineering programs may be due to a lack of comprehension regarding engineers' work. To help students understand engineers' work, providing students with immersive experiences with engineering professionals would be a practical approach, which can be achieved through outreach programs.

Several studies highlight the advantages of outreach programs on students' perceptions of STEM disciplines [10]. For example, outreach programs integrating engineering into the school curriculum have positively affected students' perceptions of engineering. Plant et al. (2009) examined how using computer-animated interface agents impacted the math performance and attitudes of 106 middle school students related to the usefulness of math and hard sciences, discovering that interaction with a female agent led to fewer gender-related perceptions of engineering in male students, while females' perceptions remained unchanged [11]. Hirsch et al. (2018) found that middle school students who were introduced to engineering within their math and science curriculum developed more positive attitudes towards engineering and possessed greater knowledge of engineering careers than those who did not encounter engineering concepts in their curriculum [12].

This summer high school transportation camp program aims to boost the number of students engaging in advanced degrees and careers in science, technology, engineering, and math (STEM) related to transportation, specifically focusing on enhancing participation among women and minority groups. Over time, the initiative aims to help cultivate a workforce equipped with STEM skills. To realize these aims, the program has set the following objectives: 1) Reach out to minority youth, young women, and disadvantaged individuals to make them aware of the opportunities available in transportation-related STEM careers. 2) Heighten awareness among high school students about the vast array of fulfilling careers in the transportation sector. 3) Motivate and inspire high school students from varied backgrounds to think about pursuing a career in transportation.

The impact of the summer high school transportation camp program goes beyond just those who participate directly. The program supports personal development by encouraging more students to pursue advanced degrees and careers in STEM-related to transportation. It enhances the overall innovation and vitality of the transportation sector. Additionally, our commitment to increasing the participation of underrepresented groups, including women and minorities, enriches the diversity and inclusivity of the industry, resulting in more well-rounded solutions and a workforce that mirrors the society it serves. Over time, our dedication to creating a STEM-skilled workforce will ensure that the transportation industry stays at the leading edge of technological innovation, sustainability, and resilience. Our program actively contributes to a brighter future for aspiring young talent and the transportation sector through outreach, raising awareness, and providing inspiration.

Program Description

During the program planning and development phase, the organization team emphasized strategies to attract diverse young individuals to engage in transportation-related STEM fields. First, they were directly involved with several high schools serving underrepresented students to provide them with program information and encourage participation. Second, the entire camp is free for all students. Additionally, they developed plans to offer financial support to students who might require assistance with travel expenses from their hometowns to the camp locations. Third, the planning and development team comprises experts in multiple disciplines, including civil engineering, transportation engineering, urban design and planning, and construction management. This diverse expertise allowed them to create a curriculum that incorporated a wide range of perspectives and experiences. Lastly, they implemented a systematic approach to collect demographic data about program participants. These data served as a valuable tool for measuring the effectiveness of our diversity, equity, and inclusion efforts. These efforts collectively reflected the commitment to fostering diversity in the program, ensuring that all young individuals can explore and thrive in STEM fields related to transportation.

Camp Application and Student Cohort

To create a thorough set of criteria for evaluating students, the program utilized suggestions from the National Summer Transportation Institute Program Desk Reference, a document produced by the U.S. Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) [13]. Their recommended criteria encompassed aspects such as students in grades 7 through 12, completion of introductory algebra or qualification for enrollment in algebra for the forthcoming school year, interest in pursuing a STEM education, and a minimum cumulative

GPA of 2.0 or higher on a 4.0 scale. Based on these guidelines, to qualify for the program, participants were required to satisfy the following conditions: 1) Interest in Transportation. The program prioritized students who exhibited a genuine interest in transportation engineering or related fields; 2) Performance: the program considered students with a fairly strong academic track record in math, science, and engineering-related courses, as they demonstrated the capability to engage with the camp's curriculum effectively; 3) Diversity, Equity, and Inclusion (DEI): the program aimed to foster a diverse learning environment by selecting students from various backgrounds and experiences, promoting inclusivity and collaboration; 4) Service Experience: the program looked for students who had demonstrated strong teamwork skills; 5) Communication Skills: the program looked for students who had strong communication skills, as well as an ability to work in groups and present their ideas; 6) Leadership Potential: the program considered students who had exhibited leadership potential in school or community activities, indicating their capacity to take initiative, work independently, and inspire others. The application review committee of the program accessed applicants by reviewing their supporting materials associated with each criterion, including personal statements, introduction videos, and letters of recommendation. Figure 1 shows the demographics of the accepted camp participants.

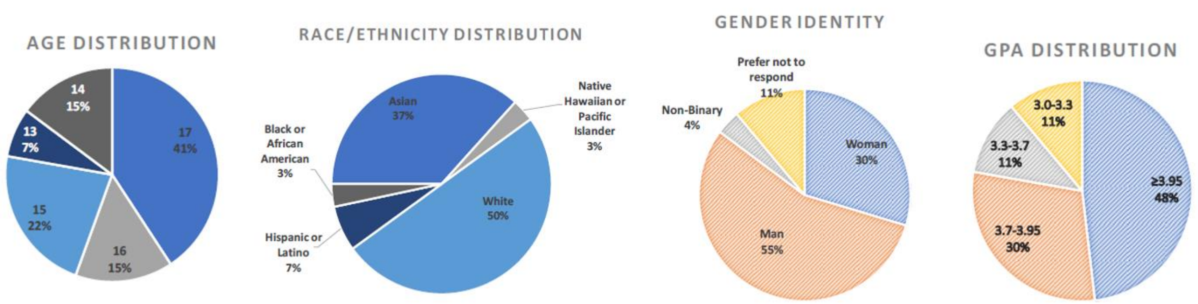

Figure 1. Accepted Participants' Demographics

Camp Curriculum Development

This camp was six days and five nights long. The experiential learning theory guided the curriculum development. Experiential learning represents the process of learning through experiences. Involvement in real-world activities helps students effectively transform the knowledge learned from university into actual applications [14]. Conventional lecture-based approaches may establish a relatively didactic and passive learning environment for students. On the contrary, students are immersed in a practical and active learning environment through experiential learning, which can potentially reinforce their understanding of knowledge. The most prestigious experiential learning theory was proposed by Kolb, who defined experiential learning as "the process whereby knowledge is created through the transformation of experience" [15]. Kolb's experiential learning theory depicts a cyclic model of learning, including (i) concrete experience, (ii) reflective observation, (iii) abstract conceptualization, and (iv) active experimentation [15]. Specifically, the cycle initializes with concrete experiences, meaning learners actively gain experiences from current or previous involvements. During reflective observation, learners should reflect on their experiences and obtain insights from the experiences. In the third phase, learners can conceptualize a new theory or form a conclusion based on their reflection in the second phase. Finally, learners apply their invented theory as a reference to engage in future real-world scenarios. These four phases perfectly represent the integral learning components: experiencing, reflecting, thinking, and acting. While concrete experience is typically considered the first phase, it is worth noting that learners can initialize this learning cycle with any phase and follow its logical sequence.

Camp Activities and Student-Led Project

Guided by the experiential learning theory, the camp activities were designed around five main themes: 1). Introduction to Transportation; 2) Transportation Safety and Equity; 3) Active Transportation, Public Transit, and Sustainability; 4) Integrated Transportation System, Supply Chain; and Logistics; 5) Transportation Technology. The five themes were logically assigned to each day of the week (Monday through Friday) based on the progression from foundational knowledge to more advanced topics. Guided by themes, seven daily learning objectives were defined, serving as the foundation for developing camp activities, including participatory lectures, team projects, evening activities, field trips/site tours, and lab visits. The seven learning objectives were to identify how transportation impacts society and daily life, to explore transportation inequities and disparities among communities, to understand key safety concerns in transportation and their variation across communities, to compare transportation modes and their benefits, availability, and effectiveness for different communities, to link transportation usage to environmental impacts, especially regarding climate change, to recognize emerging technologies in transportation and their societal impact, and to discuss how technology can transform daily transportation experiences. Table 1 lists the activities designed for the camp, and Figure 2 shows photos of those activities.

Table 1. Activities Designed for the Camp

Activity	Description
Participatory Lectures	Twelve guest speakers gave a total of 10 interactive lectures. Each lecture topic was designed to tie in with the daily theme as well as connect with the student-led team project, enabling students to apply the knowledge gained in the lectures to practical scenarios.
Field Trip, Tours, and Lab Visits	Students had the opportunity to experience four field trips, one lab visit, and one guided walking tour.
Evening Activities	Teamwork on the project and recreational activities, including ice breaker, movie night, local community redesign presentation, and game night.
Student-Led Team Project	The student-led team project centered around the design of a complete street, empowering each team to choose a familiar community and envision improvements for its transportation.

Figure 2. Photographs of Camp Activities. Clockwise from the top left: a participatory lecture, student-led team project, field trip, and project presentation.

Table 2. Student-led Team Project for the Camp

Project Daily Activity	Key Output	Experiential Learning
Day 1: Introduce Project	Project Location Selected	Concrete experience
Day 2: Identify Issues	List of Issues Identified	Reflective observation
Day 3: Brainstorming Solutions	List of Ideas/Solutions to Identified Issues	Abstract conceptualization
Day 4: Implement Solutions	Final Drawn Changes to Project Area	Active experimentation
Day 5: Prepare for the Final Presentation	Poster and Final Presentation	

The student-led team project was the center activity of this camp, as it provided students with a rich learning environment for their experiential learning. The project would be developed over the five days during the camp. Table 2 describes the project activity for each day and the corresponding experiential learning stage. Students were challenged to understand and describe the challenges and opportunities present in transportation in communities and apply fundamental principles of engineering, management, and urban planning in improving transportation within the selected community.

The students began by exploring the project topic and learning fundamental concepts, including an introduction to complete streets. Each student team selected a project location, ranging from a single street to an entire neighborhood. To support an experiential learning environment, they were also engaged in a presentation of a recent complete street redesign and a walking tour. Following this, the teams identified key transportation issues of their chosen project area, such as safety, mobility, accessibility, and equity, complemented by insights from our camp activities. Students then brainstormed creative and innovative solutions to address those problems by integrating their experience with observations learned through our camp. These solutions were then illustrated on large printouts of their selected project area, showcasing the proposed changes and positive impacts on communities. Such changes included adjustments to transportation infrastructure, alterations in land use, or any other innovative ideas proposed by the students. Students presented their completed posters to their peers, parents, and other attendees on the final day.

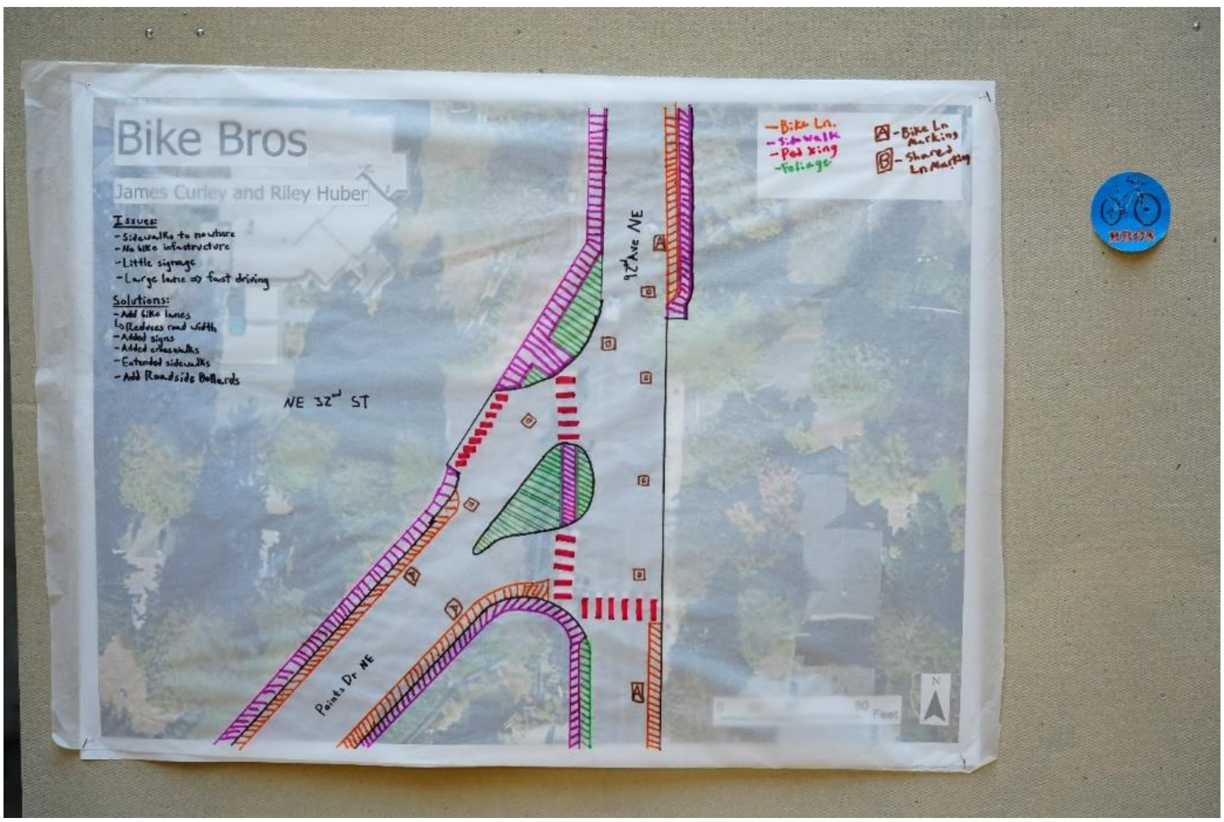

Figure 3. A sample of students' project work

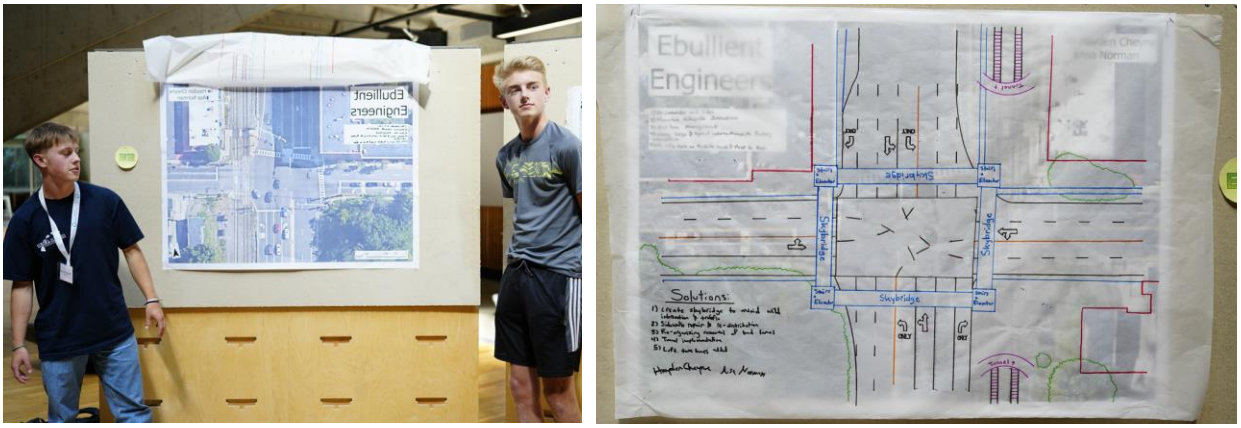

Figure 4. Students' Project Work and Presentation

Figure 3 shows a sample of students' project work. They used the intersection of NE 32nd Street and Points Drive, Yarrow Point, WA, as their study area. They have identified four issues with the current road design: sidewalks leading to nowhere, no bike infrastructure, little signage, and large (wide) lanes resulting in fast driving. They proposed the following solutions: add bike lanes leading to reduced lane width for cars, add signs, add crosswalks, extend sidewalks, and add roadside bollards for safety.

Figure 4 shows the project and presentation of another group of students. They identified multiple issues related to transportation and traffic design, including no crosswalk on both sides of the road, numerous sidewalk obstructions, poor lane management, overly large intersections with the railway interaction, and a lack of left turns. After that, they proposed solutions to solve these issues that they found. For example, they designed a sky bridge to avoid wild intersections and traffic. Students gave plans for sidewalk repairs, re-engineering of pedestrian and bike lanes, tunnel implementations, and adding more left turns.

Assessment

Assessment of Student Learning

In alignment with the camp schedule and the identified daily learning objectives, the program developed a set of pre- and post-survey questions to evaluate student learning effectiveness on each topic. The survey was geared towards looking for changes in their perceptions. Both the pre- and post-surveys consisted of seven identical, multiple-choice questions. Students were asked to self-assess how well they understood a transportation-related concept: Quite well, Somewhat well, or Not well. *Quite well* indicates that they could explain these in detail. *Somewhat well* means they could explain certain aspects in detail, and *Not well* reflects that they could only explain minimal details. In the post-survey, all students were asked an open-ended question: "*Please share any additional insights you gained during the camp that might not have been covered in the previous questions*." The results of students' pre- and post-survey results and results comparison can be found in Table 3. For example, 8% of students believed they understood their community's transportation options well before attending the camp. By the time they completed the study at camp, 88% of students answered "Quite well" to the same question.

The same pattern was observed for all other questions. In other words, the camp enhanced students' learning effectiveness on the five main transportation engineering-related themes.

Table 3. Students' Pre-Survey and Post-Survey Results

Question		Pre-Survey	Post-Survey
1. How well do you feel you understand your community's transportation options?	Quite well	**8%**	**88%**
	Somewhat well	80%	12%
	Not well	12%	0%
2. How well do you understand your community's shortcomings with regard to transportation options?	Quite well	**32%**	**88%**
	Somewhat well	32%	8%
	Not well	36%	4%
3. Do you notice any parts of your community that are less well served by transportation options than others?	Quite well	**32%**	**68%**
	Somewhat well	44%	32%
	Not well	24%	0%
4. Can you describe the safety concerns present in your community?	Quite well	**16%**	**64%**
	Somewhat well	56%	36%
	Not well	28%	0%
5. Can you describe aspects of your community where multi-modal options are prevalent and where they are lacking?	Quite well	**36%**	**84%**
	Somewhat well	48%	16%
	Not well	16%	0%
6. Can you describe the issues surrounding sustainability present in our transportation network?	Quite well	**24%**	**76%**
	Somewhat well	44%	24%
	Not well	32%	0%
7. Can you describe how technology plays a role in addressing the transportation challenges highlighted?	Quite well	**20%**	**80%**
	Somewhat well	48%	16%
	Not well	32%	4%

Assessment of the Program

Additionally, the program created a survey for students to assess the camp. The survey covers several aspects of the camp, including Camp Experience, Camp Activities and Learning, Camp Organizers and Staff, Facilities, and Accommodations. On a scale of 1 to 5, students rated how much they agreed with the statements (1 being poor and 5 being excellent). Table 4 summarizes the key findings from the survey, which was completed by 17 students (out of 25). Figure 5 shows the pre- and post-assessment results of the program. As shown in the pie charts, almost all students agreed that the knowledge they learned largely increased after attending this camp program. The students were satisfied with the camp, given their levels of satisfaction, their ratings of activities, and their likelihood of recommending this camp to friends and classmates. The top two reasons given by students for attending this camp were "career exploration" and "interest in transportation." Students were especially drawn to the hands-on aspects of the camp activities. One student commented, for example, "*The asphalt and cement professor. I liked going into the classrooms and looking around. My favorite part was getting to touch the materials (he gave me a cylinder of clay!).*" Students gained better knowledge about transportation engineering through this camp. "*It showed me all of the different jobs in transportation, how almost anyone can work in it, and all of the possible jobs I could pursue*," said one student, describing their main takeaway from the camp. In addition, the parent of a student sent a thank you email after the camp, saying, "*I wanted to take the time to thank you for this summer week camp. My son [student name] truly enjoyed the experience and loved to discover the campus. He loved the science activities and made some friends.*"

Table 4. Camp Evaluation Results

Evaluation Items	**Rating**				
	Poor	**Fair**	**Good**	**Very Good**	**Excellent**
Quality of the camp lectures	0%	0%	5.9%	47.1%	47.1%
Quality of the camp tours	0%	0%	5.9%	11.8%	82.4%
The friendliness and helpfulness of the camp organizers and counselors	0%	0%	5.9%	5.9%	88.2%
How likely are you to recommend this camp to a friend or classmate?	0%	0%	0%	29.4%	70.6%

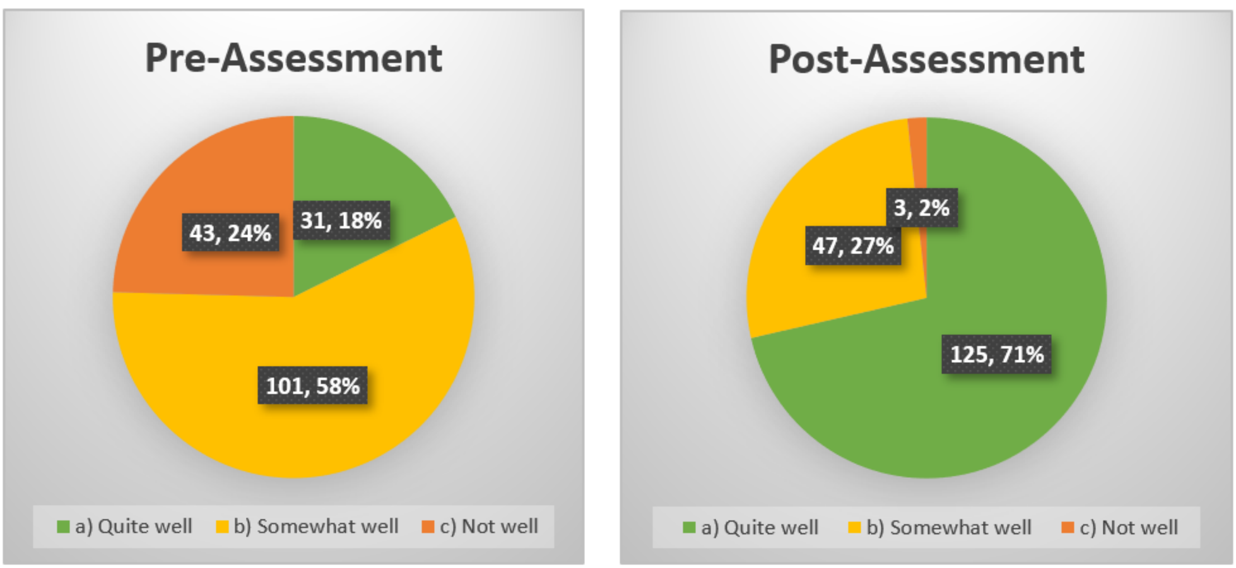

Figure 5. Comparisons of Pre- and Post-Assessment Overall Results of the Program

Discussion

Summer camps are an excellent way to introduce high school students to transportation engineering. The results show that this summer camp has successfully increased awareness of transportation engineering as a career for all students who have attended our summer program. Overall, the camp was well received by the high school students and parents. Moreover, the results of this study offer valuable perspectives on the effectiveness of implementing the experiential learning model in the development of camp curricula. Students reported that they mostly enjoyed the tours and in-person hands-on experience (i.e., team projects). The camp activities helped them understand the transportation engineering industry better. Interacting with professionals from the industry helped students gain a practical understanding of transportation projects. Also, the student-led project was designed so that students could create solutions based on their observations and information collections and then complete a presentation describing the issues and ideas. This “activities design and planning” process could help students enhance their critical thinking skills [16]. Learning should primarily be viewed as an ongoing process rooted in experience rather than a result. The ongoing nature of experience is crucial for effective learning, indicating that the knowledge and skills students acquire in one context can serve as tools for effectively navigating future situations. This process persists as long as life and learning continue [15]. While it is important for students to acquire technical skills, it is equally important for them to look beyond a particular technology. For example, students were asked to understand community impacts regarding transportation projects. The upcoming generation of professionals should be prepared with technical capabilities and have an understanding of the connections between people and the environment [17].

Along with the positive outcomes, the project has some limitations. Firstly, no follow-up survey is developed for the participating students. In future research, the program plans to distribute a survey to the students who attended the camp and are considering college after graduating high school. In subsequent studies, it would be valuable to investigate whether the effects noted in the follow-up survey responses persist over several years. Future initiatives will focus on regularly administering surveys to the camp participants to track their sustained interest in transportation engineering and their career choices after college. Secondly, no formal survey is designed for the camp organizers, consultants, and counselors to evaluate their experiences and influence on the high school students. Information regarding their mentoring experiences will be gathered and analyzed to refine the study. Thirdly, the program should evaluate how peers influence students’ experiences in the camp since the student-led project is one major activity. In general, peers influence each other in learning motivations, which is a benefit of normative or group-based learning. For example, suppose a student perceives peers who actively and enthusiastically engage in learning activities. In that case, the student, too, will engage in learning and might participate more in the activity [18]. Peer relationships can also be seen as personal relationships that have the potential to provide emotional support, which is associated with positive academic motivation, including the pursuit of goals to learn and perceived academic competence [19]. Lastly, for future study, the organizer will conduct focus group interviews to gain more insight into the program and its effectiveness. In the meantime, more sophisticated quantitative measures will be integrated to strengthen the overall study.

Furthermore, the program could also include an interactive session with parents. Family influence, in the forms of financial and social capital, advice, social support, and development opportunities, could have a substantial overall effect on the desire to study a specific major [20]. In recent years, higher education institutions have increasingly been considering engaging parents to foster student success [21]. The program could support family engagement by designing activities that give students and their families hands-on experience in transportation engineering practices. Parents as learning partners could add critical learning support during engineering-making activities [22]. Finally, incorporating international students would introduce a distinct cultural diversity that would enhance the camp experience for all participants and counselors.

Conclusions

The DOT-funded Summer High School Transportation Camp represented a pivotal moment in the continuing efforts to engage and educate future STEM professionals within the transportation sector. This immersive and enriching opportunity acted as a source of learning, exploration, and personal development for the 25 students involved. The camp's success was evident through the overwhelmingly positive feedback from both students and their parents. The involvement of the guest speakers, the interactive nature of the engaging lectures, the enlightening field trips, and the stimulating student-led team projects all significantly contributed to enhancing the educational experience. More importantly, the camp aims to spark the interest of high school students and inspire them to pursue advanced education and careers in STEM areas related to transportation. Therefore, this study seeks to assist professionals and educators in expanding participation, especially among women and underrepresented minority groups, with the goal of fostering a more diverse and inclusive workforce in STEM. In conclusion, the Camp has established a solid groundwork for future initiatives.

Acknowledgment

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