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Implementation and Outcomes of a First-time Residential National Summer Transportation Institute Pre-college Program (Evaluation)

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Abstract

In summer 2024, the Engineering Technology department at Middle Tennessee State University hosted its inaugural non-residential National Summer Transportation Institute (NSTI) program. For 2025, with continued support from the Federal Highway Administration (FHWA) and our state's Department of Transportation (DOT), we transitioned to a first-time residential model. The objective of this first-time residential NSTI program was to enhance rising high school students' familiarity with transportation-related careers, confidence in engineering and related STEM skills, and likelihood of pursuing transportation/STEM degrees and careers through an immersive four-week on-campus experience. Building on our 2024 non-residential program, the 2025 residential model incorporated extended team-building, recreational activities, dormitory living, and expanded curriculum elements to foster deeper engagement, peer bonding, and exposure to collegiate life.

The four-week program ran weekdays only (Monday through Friday), with participants residing on campus to immerse them in college life while returning home on weekends. No cost was charged to participants, as the grant covered dormitory housing, meals, activities, and transportation. The program served rising high school students (ages 13–17, grades 9th–12th rising). From approximately 60 applicants, 17 were selected based on application reviews emphasizing academic interest, essays, and recommendations; the final cohort of 15 (13 male, 2 female) reflected diverse backgrounds, with two pre-program withdrawals due to a sports injury and discomfort with dormitory living.

A typical day included morning hands-on STEM instruction (e.g., Arduino robotics, computer vision/drones, SUMO traffic simulation), afternoon field trips or projects, and evening team-building/recreation. Week 1 focused on orientation, with an opening ceremony introducing rules, expectations, and safety, as well as icebreakers to foster friendships. Weeks 2–4 emphasized curriculum enhancements (e.g., advanced robotics challenges, drones and computer vision, sophisticated SUMO simulations) and expanded field trips (e.g., airport operations, Amazon logistics). The program concluded with a closing ceremony featuring team presentations on learned concepts.

Staff comprised six members: a Program Director, Program Assistant (academic coordinator), one Computer Science faculty member, one Engineering Technology faculty member, and two undergraduate engineering majors serving as chaperones/mentors.

Pre- and post-surveys (identical to 2024) showed significant gains in transportation familiarity and skills via unpaired t-tests ($p < 0.05$), indicating greater success than the non-residential version. This paper details planning, recruitment, dorm assignment, curriculum, activities, field trips, presentations, survey results, and lessons learned, benefiting institutions hosting similar residential pre-college programs.

1. Introduction

Pre-college residential summer programs have long been recognized as an effective way to increase students' interest, confidence, and persistence in STEM disciplines. Unlike commuter-based programs, residential programs immerse participants in a sustained academic and social environment that promotes peer bonding, identity formation, and informal learning beyond scheduled instructional hours. Studies have shown that residential STEM camps can positively influence students' self-efficacy, sense of belonging, and long-term aspirations, particularly among students with limited prior exposure to college life and engineering careers [1]–[5].

The National Summer Transportation Institute (NSTI) is one such federally supported initiative designed to broaden participation in transportation-related education and careers. Funded by the Federal Highway Administration (FHWA) and administered by state Departments of Transportation (DOTs), NSTI programs aim to introduce rising high school students to transportation systems, engineering concepts, and workforce pathways through hands-on learning, field experiences, and mentorship. While NSTI programs vary widely in duration, curriculum, and delivery format, residential models are often highlighted for fostering deeper engagement, teamwork, and holistic student development [6], [7].

In summer 2024, the Engineering Technology department at Middle Tennessee State University (MTSU) hosted its first NSTI program in a four-week, non-residential format. That program emphasized daily hands-on STEM activities, robotics challenges, and transportation-focused modules while allowing students to commute from home. The organization, curriculum, and assessment outcomes of that non-residential NSTI program were reported in detail in our prior ASEE conference paper [8]. While the 2024 program achieved its primary educational objectives, feedback from students, parents, and program staff suggested that a residential format could further enhance student engagement, collaboration, and exposure to the collegiate environment.

Motivated by these observations and supported by continued FHWA funding, MTSU hosted its first residential NSTI program in summer 2025. The primary objective of the 2025 residential NSTI program was to significantly increase participants' self-reported familiarity with transportation careers, confidence in using engineering to solve real-world problems, teamwork and presentation skills, and intent to pursue STEM and transportation-related college degrees and careers, while leveraging the residential format to provide immersive, sustained exposure to college life and hands-on learning beyond the 2024 non-residential model. The residential format enabled a fundamental redesign of both curricular and co-curricular components. In addition to expanded technical content, the program incorporated structured team-building activities, recreational and social programming, and extended evening interactions, all of which are difficult to implement in non-residential settings. From an instructional perspective, the residential model allowed students to engage more deeply with complex topics, including enhanced robotics challenges, a newly introduced paper-airplane-based computer vision module, and more advanced traffic simulations using the Simulation of Urban Mobility (SUMO) platform. The residential setting also facilitated more field trips and informal discussions with faculty, college students, and transportation professionals.

This paper presents the design, implementation, and assessment of MTSU's first residential NSTI program and highlights how the residential format influenced student learning, engagement, and program outcomes. Using the same pre- and post-program survey instruments as the 2024 non-residential NSTI program, we provide a direct comparison of student perceptions and self-reported outcomes across the two delivery models. In addition, we document logistical considerations unique to residential programs, including dormitory arrangements, supervision, daily scheduling, and student well-being.

By focusing specifically on the residential NSTI experience, this paper contributes to the growing body of literature on pre-college residential STEM programs and offers practical insights for institutions considering NSTI participation or similar residential summer initiatives. The lessons learned from this transition may be particularly valuable for universities seeking to scale commuter-based outreach programs into immersive residential experiences.

The organization of the rest of the paper is as follows: Section 2 discusses planning and recruitment; Section 3 presents the program schedule and team-building activities; Section 4 showcases the curriculum changes; Section 5 discusses logistical challenges and program evaluation; finally, we conclude in Section 6.

2. Planning and Recruitment

With the additional funding support from the state DOT and FWHA, planning for the 2025 NSTI program began right after the conclusion of the 2024 non-residential program and focused primarily on transitioning to a fully residential format. While the overall program goals remained unchanged, the residential nature of the program required substantial modifications to personnel assignments, curriculum delivery, facilities usage, and daily operations.

From a curriculum planning perspective, one notable change in 2025 was the involvement of a faculty member from the Computer Science department, who was responsible for designing and delivering the final curriculum component. This interdisciplinary collaboration expanded the program's technical scope and enabled participants to engage with computational concepts from a different disciplinary perspective. In addition, planning was complicated by the department's scheduled move to a new academic building in July 2025. As a result, significant portions of the senior design laboratory and associated equipment were unavailable during the program. To accommodate this constraint, several hands-on activities were redesigned, and details will be provided in Section 4.

Because participants resided on campus throughout the program, staffing needs extended beyond instructional support. Two undergraduate students majoring in Mechatronics Engineering were recruited and hired to serve dual roles as daytime chaperones and evening resident assistants. Their responsibilities included supervising participants during non-instructional hours, assisting with transitions between activities, and serving as near-peer mentors. Their presence was essential for maintaining participant safety, supporting residential life logistics, and fostering a positive living-learning environment.

In contrast to the previous year, the Program Director (PD) assumed direct responsibility for coordinating all field trips and on-campus recreational and team-building activities. This centralized coordination simplified scheduling, ensured consistency across activities, and allowed closer integration between curricular content and experiential learning opportunities. The residential format also enabled greater flexibility in scheduling activities in the evenings, which was taken into account during the planning process.

Recruitment for the 2025 NSTI program occurred concurrently with planning activities. Interest in the residential program was strong, with approximately 60 students submitting applications. After a competitive review process, 17 students were admitted. Ultimately, two admitted students were unable to participate: one withdrew due to a sports-related injury, and the other declined because she was no longer comfortable with living in a dormitory setting. The final cohort consisted of 15 participants, including 13 male and 2 female students. All participants were housed in double-occupancy dormitory rooms. The PD reserved the dorms months before the summer program started and assigned the rooms based on factors such as gender and age.

The planning and recruitment processes for the 2025 NSTI program underscored the additional logistical complexity associated with residential pre-college programs. At the same time, they laid the foundation for a more immersive educational experience that extended beyond the classroom and into participants' daily campus life.

3. Program Schedule

The 2025 NSTI program was conducted over four weeks, beginning the week after Independence Day and concluding in early August. Unlike the fully non-residential format used in 2024, the 2025 program adopted a partial residential (weekday residential) model. Participants arrived on campus each Monday morning and resided in university dormitories from Monday through Friday, returning home on Friday afternoon. This structure provided many of the benefits of a residential summer program—such as increased peer interaction, extended learning opportunities, and exposure to campus life—while reducing the challenges associated with continuous multi-week residency. This approach was particularly appropriate, given that some participants were as young as 13 and preferred not to be away from home for extended periods.

The program officially began with an opening ceremony on the first Monday, during which students and parents or guardians were introduced to program expectations, safety procedures, rules of campus life, and the overall schedule. The first several days of the program placed a deliberate emphasis on team building and friendship formation. Structured icebreaker activities, collaborative challenges, and on-campus recreational sessions were integrated into the schedule to help participants become comfortable with one another and with the residential environment before transitioning into more technically intensive coursework.

On a typical weekday, mornings were dedicated to structured STEM instruction and hands-on activities, which are described in detail in Section 4. Afternoon periods were reserved for field trips, team-based projects, and recreational or enrichment activities. The residential format also enabled informal evening interactions, including reflection sessions and supervised recreational time, which further reinforced learning and peer bonding.

Compared with the previous year, the 2025 program included an expanded set of field trips to expose participants to a broader range of transportation systems, logistics operations, and engineering careers. In addition to returning visits that were well received in 2024, new field trips were added to major regional transportation and logistics facilities, including the Nashville International Airport and an Amazon fulfillment center. These visits provided participants with firsthand exposure to aviation operations, airport infrastructure, and large-scale logistics and supply chain systems, thereby broadening their understanding of transportation beyond traditional roadway-focused examples.

The program concluded with a closing ceremony during the final week. Participants delivered team-based presentations to parents or guardians, university administrators, and representatives from the state DOT. These presentations highlighted the technical skills, projects, and transportation concepts learned throughout the program, as well as students' reflections on their residential NSTI experience.

4. Team Building Activities and NSTI Curriculum

4.1 Team Building Activities

To promote collaboration, communication, and problem-solving skills early in the program, three structured team-building activities were conducted during the first week of the residential NSTI program. These activities were intentionally scheduled before the more technically intensive curriculum modules to help participants build rapport and become comfortable working in teams. The first activity was the Spaghetti and Marshmallow Tower Challenge, a widely used engineering design exercise. Participants were divided into small groups and given a fixed set of materials (uncooked spaghetti, mini marshmallows, masking tape, and string) to construct the tallest free-standing tower within a specified time limit. The challenge required teams to plan, prototype, test, and iterate under constraints, while emphasizing teamwork and effective communication. At the end of the activity, the completed towers were measured, and the team with the tallest stable structure was recognized. See Fig. 1 for photographs of representative towers constructed by the participants.

Figure 1: Spaghetti and Marshmallow Towers built by the participants

The second team-building activity was an Egg Drop Challenge designed to reinforce concepts in impact mitigation, structural design, and creative problem-solving. Working in teams, participants designed and built a protective structure intended to prevent a raw egg from breaking when dropped from the second floor of a campus building. Teams were required to work within material and time constraints and to justify their design choices prior to testing. The activity culminated in a live drop test, during which teams evaluated the effectiveness of their designs based on whether the egg remained intact. See Fig. 2 for some of the photos taken during the drop test.

Figure 2: Egg Drop Test

The third team-building activity was a Rube Goldberg Workshop conducted at the university's makerspace. Participants were divided into small groups and tasked with designing and constructing a Rube Goldberg machine capable of completing a simple, predefined task through a sequence of mechanical actions. The activity emphasized creativity, systems thinking, and coordination among team members, as successful designs required careful planning of energy transfer, timing, and component interactions.

Groups were encouraged to brainstorm, sketch their concepts, and iteratively test and refine their designs using the available makerspace resources. At the conclusion of the workshop, each team demonstrated its Rube Goldberg machine and explained its design logic, the challenges encountered, and the lessons learned. The demonstrations highlighted a wide range of design strategies and showcased participants' ability to integrate mechanical, structural, and logical elements into a coherent system. Fig. 3 includes a few designed Rube Goldberg machines.

Figure 3: Rube Goldberg workshop

This activity further strengthened teamwork and communication skills, introduced participants to the makerspace environment, and reinforced the importance of iterative design in engineering practice. Together, these team-building activities established a collaborative learning environment, encouraged peer interaction, and introduced students with diverse backgrounds and prior experiences to engineering design.

4.2 Arduino and robotics

As in the previous year, the first curriculum component focused on Arduino programming and mobile robotics and was delivered during the initial portion of the four-week program (Week 1 and the beginning of Week 2). The same off-the-shelf robotic platform, the OSOYOO V2.1 Smart IoT Robot Car Kit for Arduino, was used due to its low cost, modular design, and suitability for beginners. The kit includes a structured set of introductory lessons and example projects that guide students through basic circuit construction, sensor integration, motor control, and Arduino programming.

Because the department was relocating to a new academic building during the summer of 2025, access to machine tools and fabrication equipment in the senior design laboratory was limited. As a result, the robotics activities were intentionally redesigned to emphasize rapid prototyping with lightweight, readily accessible materials rather than metal fabrication. This constraint shifted the design focus toward creativity, structural efficiency, and problem-solving under realistic resource limitations.

Participants were organized into two-person teams and progressed through the introductory lessons at a similar pace, despite about half having little or no prior experience with Arduino or programming. With guidance from undergraduate mentors, teams successfully completed the foundational exercises and were then encouraged to modify and extend the example projects in preparation for the robotics challenges.

Two robotics competitions were incorporated into this component.

Robotics Competition #1: Sumo Robotics

In the sumo robotics challenge, teams modified their robots and competed in a ring, aiming to push opposing robots out of the boundary. Unlike the previous year, participants did not perform metal cutting or machining. Instead, they used cardboard and other lightweight materials to design bumpers, wedges, and shields that could be attached to their robots. This approach encouraged experimentation with geometry, weight distribution, and attachment methods while maintaining safety and accessibility. As shown in Fig. 4, the competition remained highly engaging, and teams demonstrated a wide range of mechanical design strategies despite the simplified materials.

Figure 4: Sumo competition

Robotics Competition #2: Line-Following Maze Challenge

In place of the indoor soccer competition used in the non-residential program, a line-following maze competition was introduced in 2025. In this challenge, teams programmed their robots to autonomously detect and follow black lines on a maze (Fig. 5) using infrared (IR) sensors. The objective was for the robot to successfully navigate the maze with minimal deviation and without human intervention. This competition placed greater emphasis on sensor calibration, conditional logic, and algorithmic thinking, thereby strengthening participants' understanding of feedback, control, and autonomous navigation. The maze-based challenge proved to be an effective way to introduce core robotics and control concepts in a structured yet competitive setting.

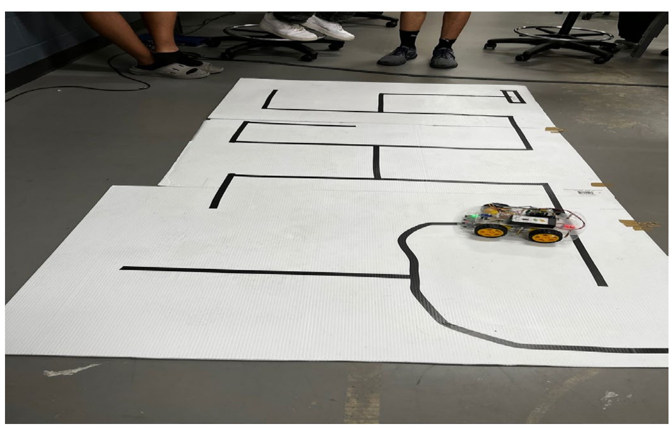

Figure 5: Line-following maze

Overall, the Arduino and robotics component provided a strong foundation in hands-on engineering, programming, and teamwork. The modifications made in 2025 demonstrate how meaningful learning outcomes can still be achieved under facility and equipment constraints, while also expanding the balance between mechanical design and autonomous control.

4.3 Drones and computer vision

The drones and computer vision components took place in Weeks 2 and 4 of the program. It followed a structured, progressive learning approach that combined simulation-based training with hands-on experimentation. Compared with the previous year's program, which utilized a single quadcopter platform, the 2025 curriculum was expanded to include two types of drones: a quadcopter drone and a fixed-wing drone. The addition of the fixed-wing platform enabled participants to directly compare the flight characteristics, control strategies, and operational constraints of rotary-wing and fixed-wing aircraft. This revision also allowed students to gain experience with both indoor and outdoor drone operations.

Figure 6: Learning to fly drones with drone simulators to navigate quadcopter and fixed-wing drones in different simulation environments.

The learning process began with a drone flight simulator, as illustrated in Fig. 6. Participants were provided with physical drone remote controllers and used them to operate simulated quadcopter and fixed-wing drones across a variety of virtual environments. Simulation scenarios spanned indoor and outdoor settings with increasing levels of difficulty, allowing students to gradually build confidence and proficiency before transitioning to real-world flight. This simulator-first approach helped reduce safety risks and improve student readiness for hands-on drone operation.

Figure 7: Flying of fixed-wing drones

Unlike the previous year's program, the 2025 curriculum incorporated a group-based fixed-wing drone assembly activity. Participants worked in pairs to assemble a fixed-wing drone from a do-it-yourself (DIY) kit, an exercise that emphasized teamwork, mechanical understanding, and attention to detail. The assembly process required close collaboration between team members and provided insight into airframe structure, control surfaces, and propulsion systems. After assembly, students conducted supervised outdoor flight tests of the fixed-wing drones, as shown in Fig. 7.

In parallel with flight training, participants were introduced to computer vision concepts through hands-on programming activities. One module focused on drone-based face tracking. Students were initially provided with example face-tracking code designed to run on personal computers. They were tasked with understanding the code structure, tuning the proportional–integral–derivative (PID) control gains to improve tracking performance, and evaluating system responsiveness. After achieving satisfactory performance on the PC platform, participants migrated the face-tracking algorithm to a Tello quadcopter, enabling autonomous face tracking during flight.

A second computer vision module addressed object recognition using the YOLO (You Only Look Once) framework. Participants trained and tested models to detect multiple object classes commonly found in transportation environments, including pedestrians and vehicles. The object detection algorithms were subsequently deployed on drones, allowing students to observe real-time recognition during flight. Under supervision, participants conducted outdoor experiments in parking lots and nearby streets to identify cars and pedestrians, as illustrated in Fig. 8. This activity exposed students to realistic sensing challenges, including lighting variation, motion, and background clutter.

Overall, the expanded drones and computer vision components provided a richer, more immersive learning experience than the previous year. By integrating simulation, hardware assembly, flight testing, control tuning, and computer vision deployment, the curriculum reinforced core concepts in aerospace systems, robotics, and intelligent transportation applications.

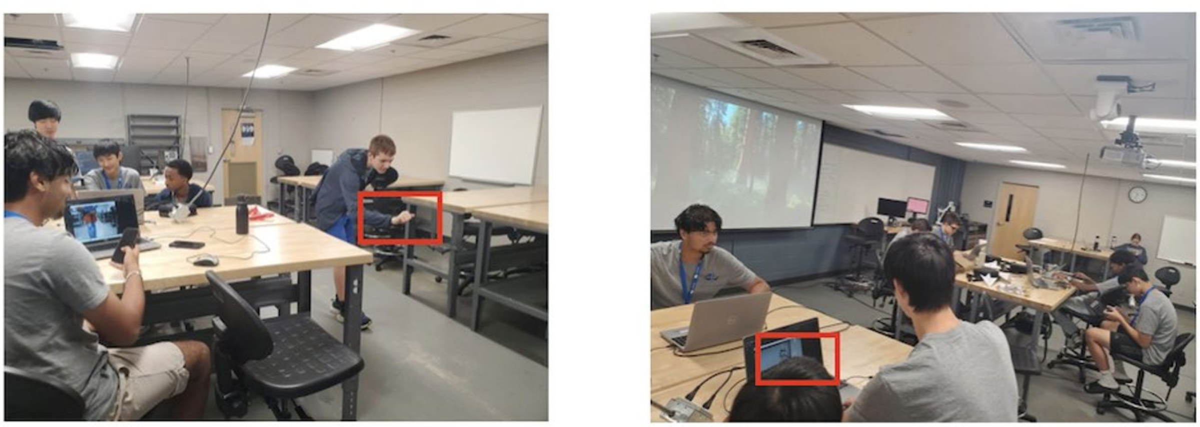

Figure 8: Learning of computer vision, including face recognition and object tracking

4.4 Traffic Systems Simulation

Traffic system simulation was carried out in Week 3 of the program. It provided a cost-effective, scalable means to study interactions among vehicles, pedestrians, and roadway infrastructure, enabling transportation engineers to evaluate system performance and identify potential operational issues before deployment in real-world environments. As part of the NSTI curriculum, students were introduced to traffic modeling using the open-source Simulation of Urban Mobility (SUMO) platform, which supports intermodal traffic simulation, including private vehicles, public transit, bicycles, and pedestrians.

Compared with the 2024 NSTI program, the 2025 traffic simulation module was significantly expanded in both depth and realism. While the previous year focused on conceptual network construction and progressively complex synthetic networks, the revised curriculum emphasized structured project-based learning, continuous vehicle generation, traffic signal control, visual performance indicators, and the use of real-world roadway data. Because none of the participants had prior experience with SUMO, instruction began with a guided introduction to the software and installation process, followed by six carefully scaffolded projects adapted and expanded from examples provided on the official SUMO website.

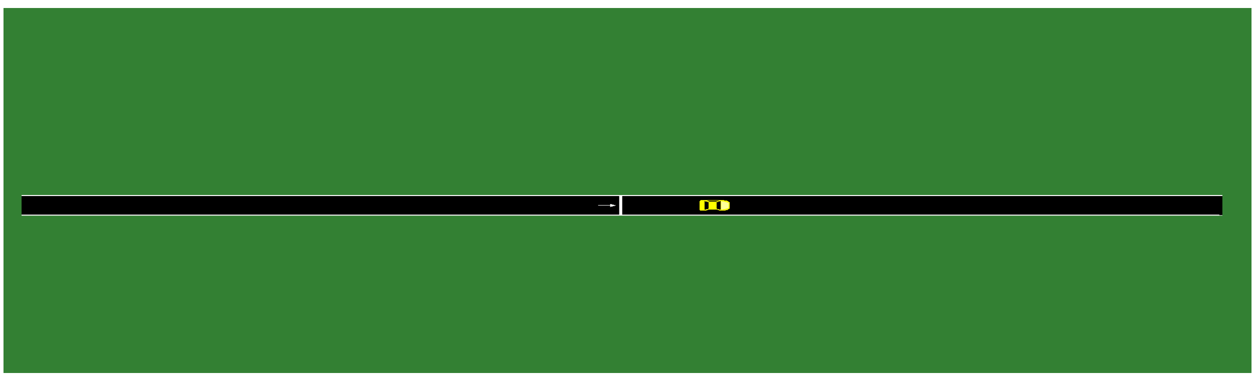

Figure 9: A simplest case of road traffic.

Project 1 introduced the most basic SUMO workflow, including creating a simple unidirectional roadway using the NetEdit tool, defining nodes and edges, generating a single vehicle, and running the simulation using the SUMO graphical user interface (sumo-gui). As shown in Fig. 9, this project familiarized students with the core components of a SUMO simulation and basic visualization.

Building on this foundation, Project 2 introduced continuous traffic flow by constructing a circular roadway network. Students created a diamond-shaped loop that allowed vehicles to circulate indefinitely, thereby preventing premature simulation termination due to finite demand. Multiple vehicles of the same type were generated by modifying vehicle identifiers and visual attributes such as color (Fig. 10). This project reinforced the concept of routing and continuous demand generation.

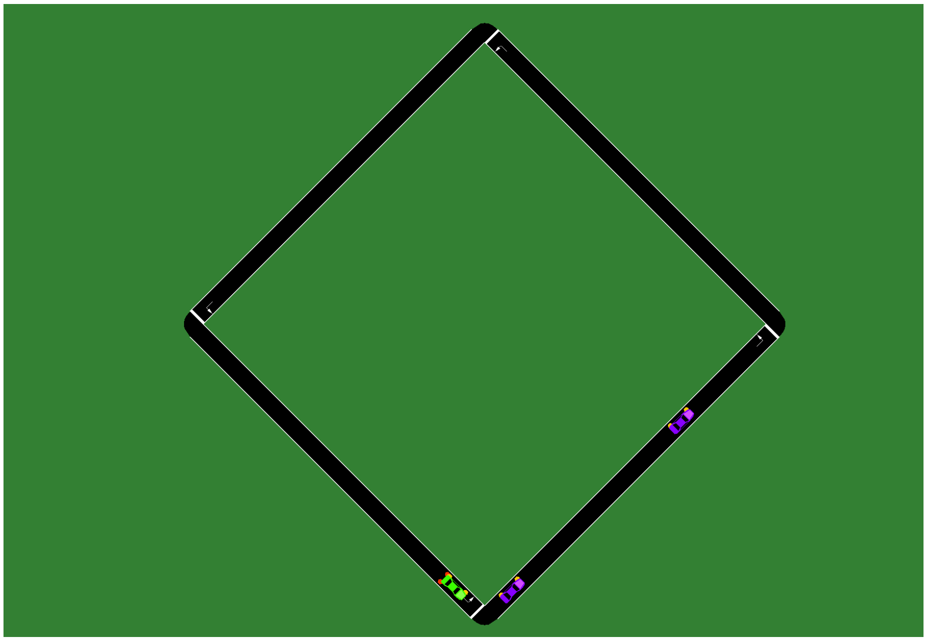

Figure 10: A circular roadway network with multiple vehicles of the same type.

To improve realism, Project 3 introduced multiple parallel lanes representing different transportation modes, including trains, buses, bicycles, and pedestrians. Each mode operated on a dedicated lane, and vehicle generation was implemented using flow-based demand definitions. Students also learned to implement traffic signals in NetEdit and configure basic signal timing plans (Fig. 11). This project marked the first exposure to intermodal traffic control and signalized operations.

In real-world traffic systems, different vehicle types often share the same roadway. Project 4 addressed this scenario by allowing multiple vehicle classes to operate on the same roadway segment. Students created shared lanes with defined entry and exit points and enabled a speed-based visualization feature that dynamically changed vehicle color as speed varied (Fig. 12). This visual feedback helped students intuitively understand congestion, acceleration, and deceleration patterns.

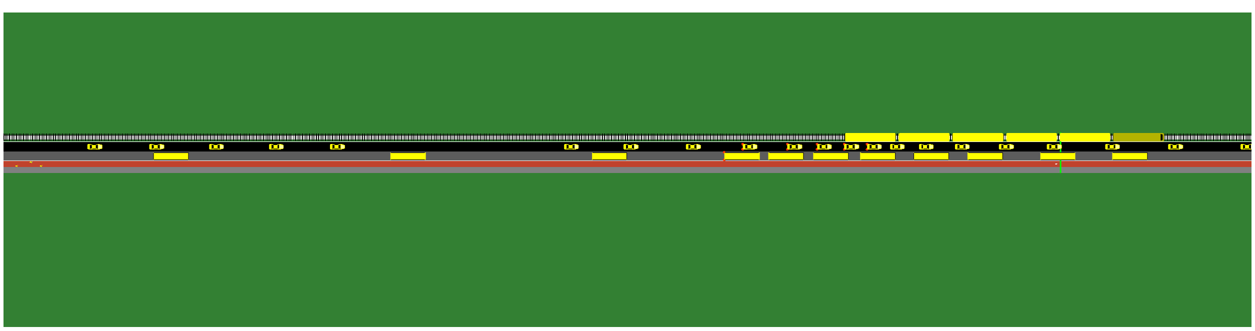

Figure 11: Multiple vehicle types on separate lanes with a traffic light.

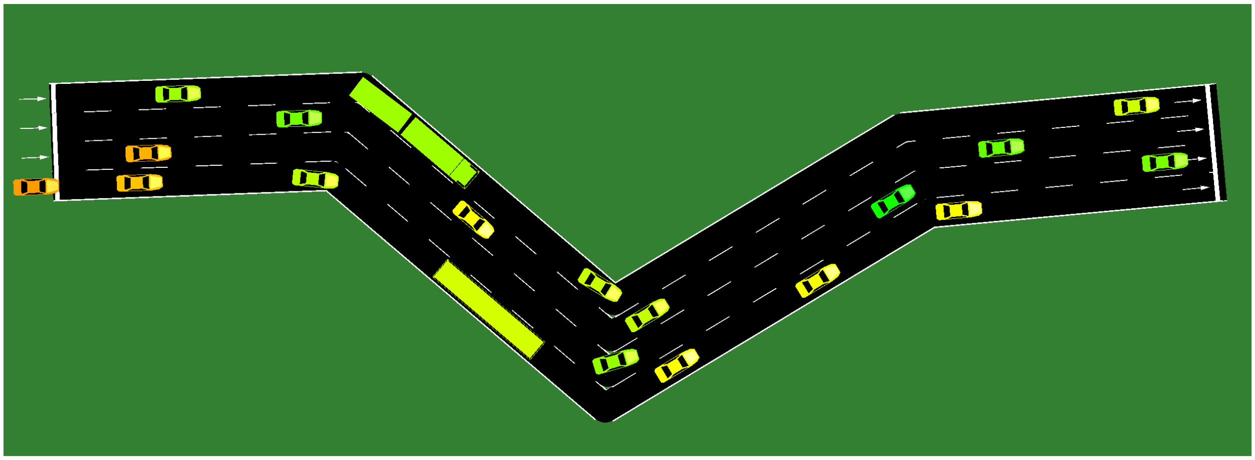

Figure 12: Multiple vehicle types on shared lanes with an entry point and an exit point.

After completing the first four projects, students were prepared to model more complex traffic networks. Project 5 focused on a signalized four-way intersection with inbound and outbound lanes in each direction. Initially, students modeled a single vehicle type to concentrate on intersection geometry and traffic signal timing design (Fig. 13). Advanced students extended this project by adding turning movements, additional lanes, and multiple vehicle types, resulting in more realistic intersection operations.

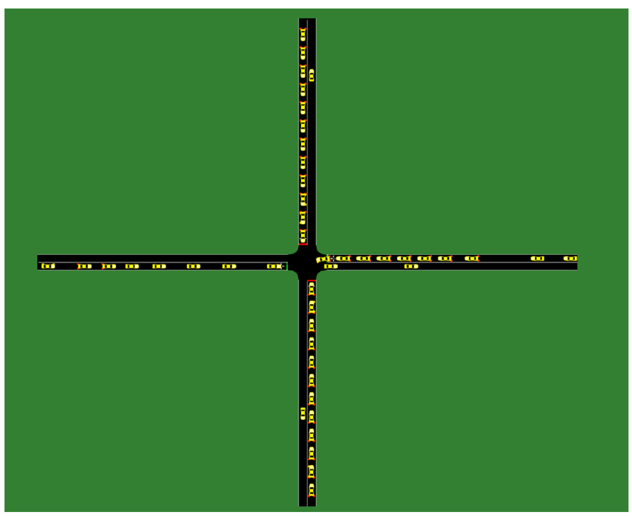

Figure 13: A simple four-way intersection with the same vehicle types

The most significant enhancement over the previous year was Project 6, which introduced the OSM Web Wizard to generate simulations based on real-world roadway data. Using OpenStreetMap (OSM), students imported the road network surrounding our university, configured a randomized traffic demand, and ran simulations with SUMO-GUI. This project allowed students to transition from abstract networks to geographically accurate models and demonstrated how simulation tools are used in professional transportation planning and analysis.

Through these six structured projects, participants progressed from simple synthetic networks to realistic, data-driven traffic simulations. Compared with the 2024 NSTI program, the 2025 curriculum enabled students to run longer, more sophisticated simulations, incorporate signal control and intermodal interactions, and analyze traffic behavior using real-world infrastructure. This expanded module strengthened students' understanding of traffic dynamics, intelligent transportation systems, and the role of simulation in modern transportation engineering, providing a strong foundation for future academic and career exploration.

5 Logistical Challenges and Program Evaluation

5.1 Logistical Challenges and Resolutions

Several minor logistical issues arose during the residential program and were addressed promptly. One participant reported a non-functional thermostat in the dormitory; housing staff inspected the unit and confirmed it was operational (the appearance was misleading due to wear). Another student inquired about nighttime access to drinking water; we advised filling reusable bottles during daytime meals, drinking tap water, or using vending machines. Staffing proved more demanding than anticipated: only two undergraduate students were hired as daytime and evening assistants/chaperones, resulting in significant overtime hours and costs due to hourly pay. In future iterations, we plan to hire additional part-time staff or adjust the compensation structure to better cover the cost of extended residential supervision.

5.2 Survey Instrument

The pre-survey consisted of seven questions using a 10-point numerical rating scale (1 = not at all/low to 10 = very/extremely high) assessing:

1. Familiarity with transportation-related careers
2. Confidence in using engineering to solve real-world problems
3. Confidence in software programming
4. Confidence in teamwork
5. Confidence in presenting technical content in public
6. Likelihood of pursuing a college degree and a career in a STEM field
7. Likelihood of pursuing a college degree and a career related to transportation

The post-survey repeated these seven items using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) phrased as statements of improvement (e.g., "The program increased my familiarity with transportation-related careers"), plus one additional recommendation item ("I would highly recommend the NSTI program to a friend").

The instrument was intentionally kept brief and straightforward. It focused on perceived changes in interest, confidence, and career intent—key outcomes aligned with NSTI goals. Although the survey instrument demonstrated face and content validity through alignment with NSTI objectives and prior studies, formal reliability and validity testing (e.g., internal consistency, factor analysis) was not conducted, which represents a limitation common to applied program evaluations with small cohorts.

5.3 Program Evaluation

The 2025 NSTI program was evaluated using pre- and post-program surveys to assess changes in participants' familiarity with transportation careers, confidence in key skills, and likelihood of pursuing STEM and transportation-related paths. A total of 15 rising high school students completed both surveys. As mentioned earlier, the pre-program survey used a 1-10 scale (1 = low, 10 = high), while the post-program survey used a 5-point Likert scale (Strongly Disagree = 1 to Strongly Agree = 5) for equivalent questions, plus an additional recommendation question. To enable comparison, post-program Likert responses were linearly transformed to the 1–10 scale using $y = (9/4)(x - 1) + 1$ to align with the pre-survey and preserve the full range.

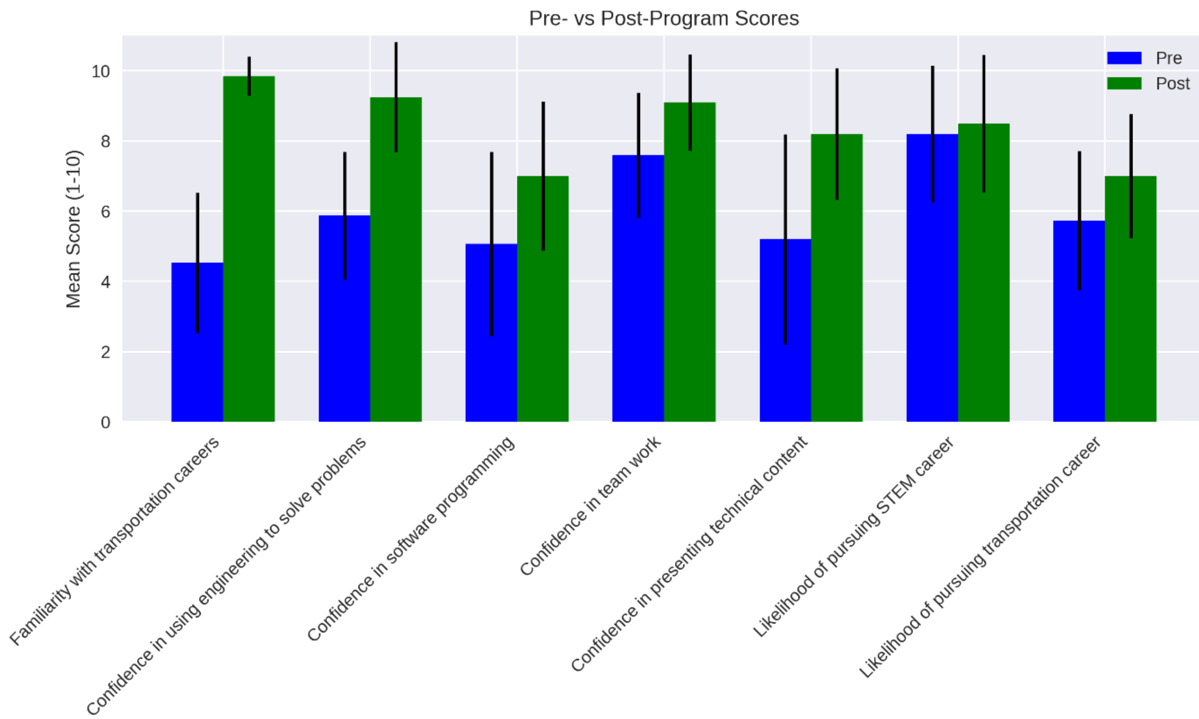

Figure 14: Distribution of pre- and post-program surveys

Fig. 14 illustrates the distributions of pre-program responses and post-program perceptions of improvement. The pre-program responses show varied baseline levels (e.g., low familiarity with transportation but high teamwork confidence). The post-program perceptions of improvement indicate strong agreement in most areas. The post-program recommendation question ("I would highly recommend the NSTI program to a friend") had a mean of 4.67 (SD = 0.79) on the 1-5 scale with 93.3% agreeing or strongly agreeing (Table 1).

Table 1. Post-Program Recommendation Distribution (n=15)

Response	Count	Percentage
Strongly Agree	12	80.0%
Agree	2	13.3%
Neural	0	0.0%
Disagree	1	6.7%

Strongly Disagree	0	0.0%

Unpaired t-tests were used to compare pre- and post-program means because surveys were collected anonymously without unique identifiers or consistent ordering, precluding reliable one-to-one participant matching. Normality (Shapiro-Wilk) and equal variance (Levene's) assumptions were verified for each question (all $p > 0.05$ except one item, addressed via Welch's adjustment). While paired tests would have been ideal if matching were possible, the unpaired approach is appropriate and conservative given the data constraints.

Table 2 presents the pre- and post-program means, standard deviations, changes, and p-values. Significant improvements were observed in five of seven areas, with the largest gains in familiarity with transportation careers (+5.52), confidence in using engineering to solve problems (+3.45), and confidence in presenting technical content (+2.54). General STEM career likelihood showed a modest, non-significant increase (+0.77), possibly due to high baseline interest.

While self-selection and our application-based recruitment process may have attracted students with some baseline STEM interest, pre-program survey responses showed moderate-to-low familiarity and interest specifically in transportation careers (means 4.33–5.47), suggesting that program effects were not solely attributable to pre-existing high motivation in the target domain.

Table 2. Pre- and Post-Program Survey Comparison (n=15)

Question	**Pre Mean (SD)**	**Post Mean (SD, scaled to 1-10)**	**Change**	**p-value**
Familiarity with transportation careers	4.33(1.99)	9.85(0.56)	+5.52	0.0000*
Confidence in using engineering to solve problems	5.80(2.04)	9.25(1.57)	+3.45	0.0000*
Confidence in software programming	5.67(2.26)	7.00(2.12)	+1.33	0.1090
Confidence in teamwork	7.07(2.46)	9.10(1.37)	+2.03	0.0266*
Confidence in presenting technical content	5.67(3.09)	8.20(1.87)	+2.54	0.0060*
Likelihood of pursuing a STEM career	7.73(2.49)	8.50(1.96)	+0.77	0.4039
Likelihood of pursuing a transportation career	5.47(1.45)	7.00(1.77)	+1.53	0.0203*

*Significant at $p<0.05$

6 Conclusions

This paper presented the implementation and evaluation of MTSU's second-year National Summer Transportation Institute (NSTI) program. In 2025, the program adopted a residential format over four weeks, featuring an immersive curriculum (Arduino programming, computer vision/drones, SUMO traffic simulation), field trips, and on-campus living. Details of organization, recruitment, schedule, activities, and outcomes are provided.

The program was highly successful, as shown by participants' strong final presentations and pre/post surveys (n=15). Unpaired t-tests (conducted due to lack of ordered participant matching) revealed significant improvements ($p < 0.05$) in transportation career familiarity (+5.33), engineering problem-solving confidence (+3.20), teamwork (+1.93), presentation skills (+2.87), and transportation career pursuit likelihood (+2.20).

Lessons learned include enhancing recruitment advertising, balancing schedules for more recreation, and deepening programming focus. These insights will inform future NSTI programs at our university and benefit other institutions developing similar pre-college initiatives to promote STEM and transportation careers among rising high school students.

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