STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

STRIDE Transportation Curriculum

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation's University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.

ACKNOWLEDGEMENT OF SPONSORSHIP AND STAKEHOLDERS

This work was sponsored by a grant from the Southeastern Transportation Research, Innovation, Development, and Education Center (STRIDE). Authors would like to thank the South Carolina Governor's School for Science and Mathematics for organizing the summer camps and providing valuable support in piloting the curriculum.

Funding Agreement Number - 69A3551747104

LIST OF AUTHORS

Lead PI:

Dimitra Michalaka, Ph.D., P.E.
The Citadel, Civil & Environmental Engineering
Dimitra.Michalaka@citadel.edu
ORCID Number: 0000-0001-7001-0579

Co-PI:

Ondine Wells
University of Florida, Instructional Designer
owells@ufl.edu
ORCID Number: 0000-0002-7398-7200

Additional Researchers:

William J. Davis, Ph.D., P.E. (AL)
The Citadel, Civil & Environmental Engineering
davisj7@citadel.edu
ORCID Number: 0000-0002-3812-8654

Kweku Brown, Ph.D., P.E.
The Citadel, Civil & Environmental Engineering
kbrown16@citadel.edu
ORCID Number: 0000-0001-6497-8479

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This project developed an innovative curriculum to introduce middle and high school students to transportation planning and technology. The curriculum addresses gaps in existing educational materials by offering three comprehensive lessons and hands-on activities focused on transportation engineering topics not covered by current curricula. Emphasizing relevance and applicability, the lesson plans feature short modules that can be used independently or combined for more in-depth learning experiences. Furthermore, insights into existing and emerging careers in transportation are highlighted. Developed by STRIDE staff and researchers, the curriculum underwent piloting in K-12 outreach programs, with the finalized version available for free through the STRIDE website. The proposed lessons encompass three major topics including Complete Streets design principles, Curb Management strategies, and Transportation Technology applications. This effort aims to inspire and educate the next generation of transportation professionals while addressing the evolving needs of the industry.

Keywords (up to 5): K-12 transportation curriculum, lesson plans

EXECUTIVE SUMMARY

This K-12 project develops a curriculum that introduces middle and high school aged students to transportation planning and technology. The curriculum aims to fill gaps in existing educational materials by providing three lessons including hands-on activities on topics related to transportation engineering. Emerging technologies and career opportunities in the transportation field are also discussed.

As part of this effort, a booklet consisting three detailed lessons on "Complete Streets," "Curb Management," and "Transportation Technology" was created. The exact activity titles are as following:

1. Activity 1: Design Streets for Everyone
2. Activity 2: Curb Design: Create an Enjoyable Downtown
3. Activity 3: Design an App for Safer School Zones

Each lesson incorporates hands-on activities and real-life scenarios to engage students and deepen their understanding of transportation engineering concepts. The curriculum is made available for free through the STRIDE website for educators and anyone interested to access at [Transportation Engineering & Design Activities for Grades 5 to 12]

Implementing this curriculum can cultivate student interest in transportation engineering and technology, raise awareness of career opportunities in the field, and enhance understanding of complex transportation issues such as complete streets design, curb management, and transportation technology. By linking content to ongoing research and incorporating hands-on activities, the curriculum has the potential to inspire students to pursue further education and careers in transportation-related fields. The lesson plans feature short modules that can be used independently or combined for more in-depth learning experiences in the classroom and beyond, including enrichment programs such as afterschool programs, summer/holiday camps, STEM events, and homeschool programs.

The curriculum was piloted during two week-long summer camps in 2023, with overwhelmingly positive feedback from the students. Feedback was collected through pre- and post-surveys. Given the positive feedback received, a week-long summer camp dedicated to transportation engineering is planned for summer 2024.

1.0 INTRODUCTION

Transportation engineers play a vital role in society by planning, designing, constructing, operating, and maintaining safe and efficient transportation infrastructure and systems for the movement of people and goods (Subudhi, 2023; Cypress Environment & Infrastructure, 2023). Their work encompasses a wide range of areas, including traffic management, public health and safety, emerging technologies such as self-driving cars, logistics, and the operation of airports, ports, and railways (Subudhi, 2023; Cypress Environment & Infrastructure, 2023). They also focus on integrating new technologies like automated vehicles, improving emissions and energy efficiency, and ensuring equitable transportation systems and planning (Subudhi, 2023; Cypress Environment & Infrastructure, 2023).

Introducing transportation engineering concepts to K-12 students is essential for fostering a deeper understanding of how transportation systems work and impact their lives and the broader community. Early exposure to these concepts can help students develop critical thinking skills and an appreciation for sustainable transportation solutions and transportation systems in general.

The field of transportation offers diverse career opportunities in engineering and beyond, including roles in planning, software development, logistics management, infrastructure design, infrastructure maintenance, and policy analysis. From engineers specializing in civil, mechanical, aerospace, traffic, or transportation to professionals in robotics, environmental science, economics, and communications, the transportation sector welcomes individuals with a variety of skills and interests.

To provide students with insight into the dynamic field of transportation engineering and its related careers, three activities designed to engage students in real-life transportation challenges. These activities utilize the engineering design process, guiding students through problem-solving and critical thinking to develop innovative solutions.

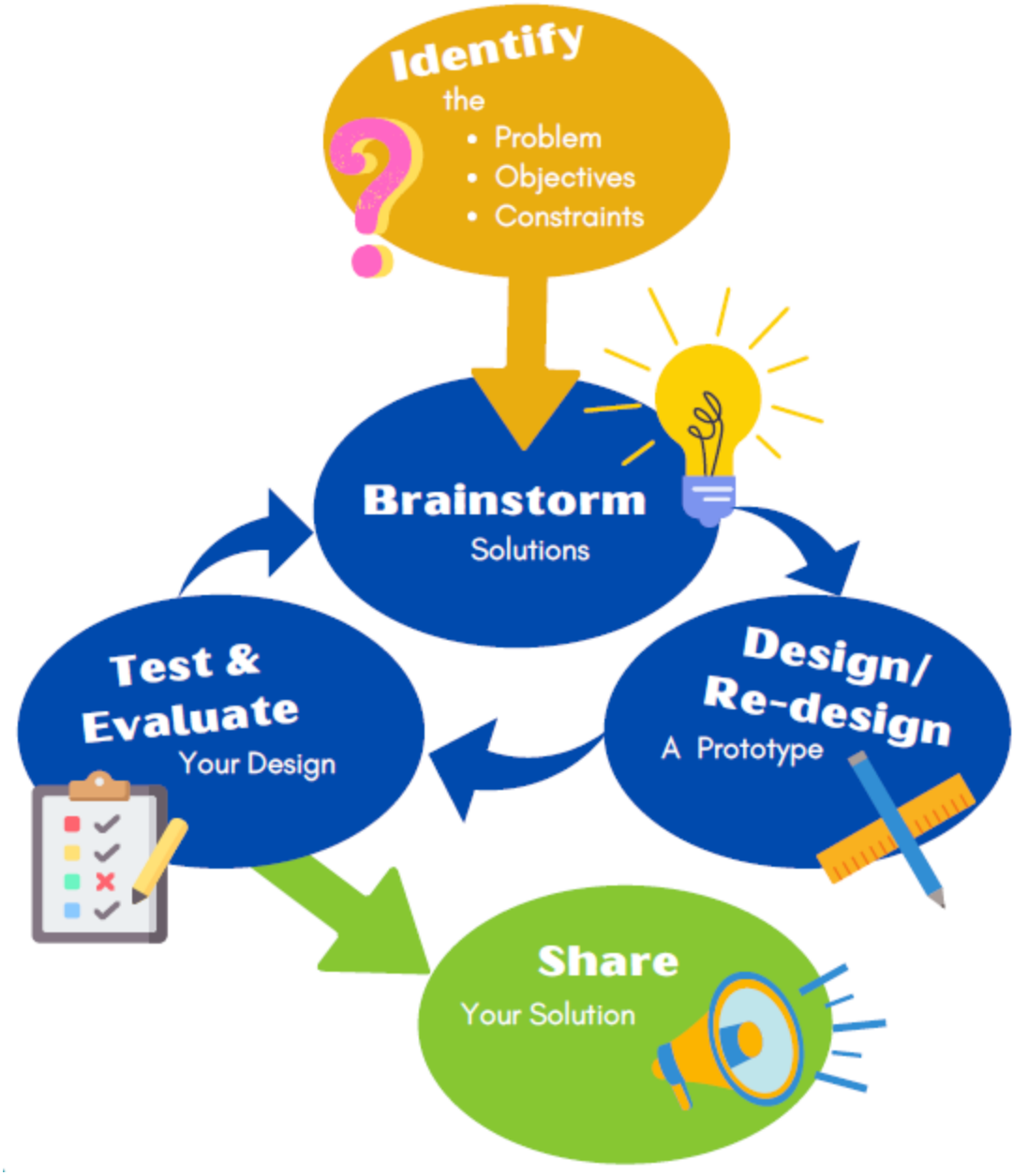

FIGURE 1: ENGINEERING DESIGN PROCESS

Figure 1 outlines the steps involved in the engineering design process and serves as a framework for the activities included in this report.

The activities provided are adaptable for students in grades 5th to 12th and can be completed within 1 to 3 hours. They are suitable for individuals, pairs, or small groups, fostering collaboration and teamwork. Additionally, these activities align with Next Generation Science Standards (NGSS) (National Academies, NGSS, 2013), addressing key concepts related to engineering design, problem-solving, and evaluation of solutions.

Next Generation Science Standards Addressed:

MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

By engaging in hands-on activities related to transportation design and problem-solving, students can develop essential skills such as defining criteria and constraints, evaluating solutions, and designing complex systems (NGSS Lead States, 2013).

There are many different careers related to transportation. Below are just some of the many options in the transportation sector:

- **Types of Engineers:** Civil, Traffic, Transportation, Computer, Safety,
- Robotics, Materials, Environmental, Mechanical, Industrial, Systems,
- Aerospace
- Planner
- Software Developer
- Logistician
- Transportation Manager
- Designer of infrastructure and technology
- Intelligent Transportation Systems Engineer
- Inventor of new devices and products
- Communications and Marketing Specialist
- Data Analyst
- Behavioral Scientist
- Economist
- Policy Analyst

A video on "Your Future in Transportation" that can give a short introduction to transportation engineering before starting working on the activities is available at Your Future in Transportation

The following report sections focus on introducing the three activities/lesson plans.

2.0 ACTIVITY 1: DESIGN STREETS FOR EVERYONE

Transportation engineers play a crucial role in shaping urban infrastructure to ensure safe and efficient mobility for all. However, conventional street designs often prioritize the needs of motor vehicles over the diverse needs of pedestrians, cyclists, and transit users (Welle et. al, 2015). Complete Streets offer a solution by integrating the requirements of all road users, regardless of their age, abilities or their mode of transportation, into the design process.

The objective of this activity is to apply Complete Streets principles to redesign an existing street, fostering a safer and more accessible urban environment. Through this exercise, participants will learn to:

- Utilize the Engineering Design Process: Participants will engage in problem-solving using the engineering design process to address real-world challenges in street design.
- Assess Existing Street Layouts: By examining familiar streets, participants will identify shortcomings in current designs concerning user safety and accessibility.
- Apply Complete Streets Principles: Through the redesign process, participants will integrate Complete Streets principles, ensuring the inclusivity of all road users.
- Real-World Application: The activity encourages the application of design challenges to real-world examples, fostering practical problem-solving skills.

Activity steps include:

1. Introduction to Complete Streets: Participants will familiarize themselves with Complete Streets principles through a concise video introduction provided by the Ontario Professional Planners Institute (Complete Streets Video).
1. Street Sketching: Participants will sketch a street they are familiar with, highlighting existing features and potential areas for improvement.
2. Street Evaluation: Through a comprehensive evaluation, participants will assess the suitability of the street design for various user groups, identifying deficiencies and safety concerns.
3. Redesign Process: Utilizing Complete Streets principles, participants will redesign the street layout, prioritizing safety, accessibility, and inclusivity for all users.
4. Evaluation of Redesign: The redesigned Complete Street will undergo evaluation to assess its effectiveness in meeting the diverse needs of users and improving overall safety and accessibility.

In addition to accommodating traditional modes of transportation such as walking, cycling, and driving, attention will be given to emerging forms of micromobility, including electric scooters and skateboards to identify safe travel routes for these alternative modes of transportation within the redesigned street layout.

Participants will be provided with help, graphics, and detailed directions on how to execute the activity. For example, Figure 2 illustrated some ways we can design a Complete Street.

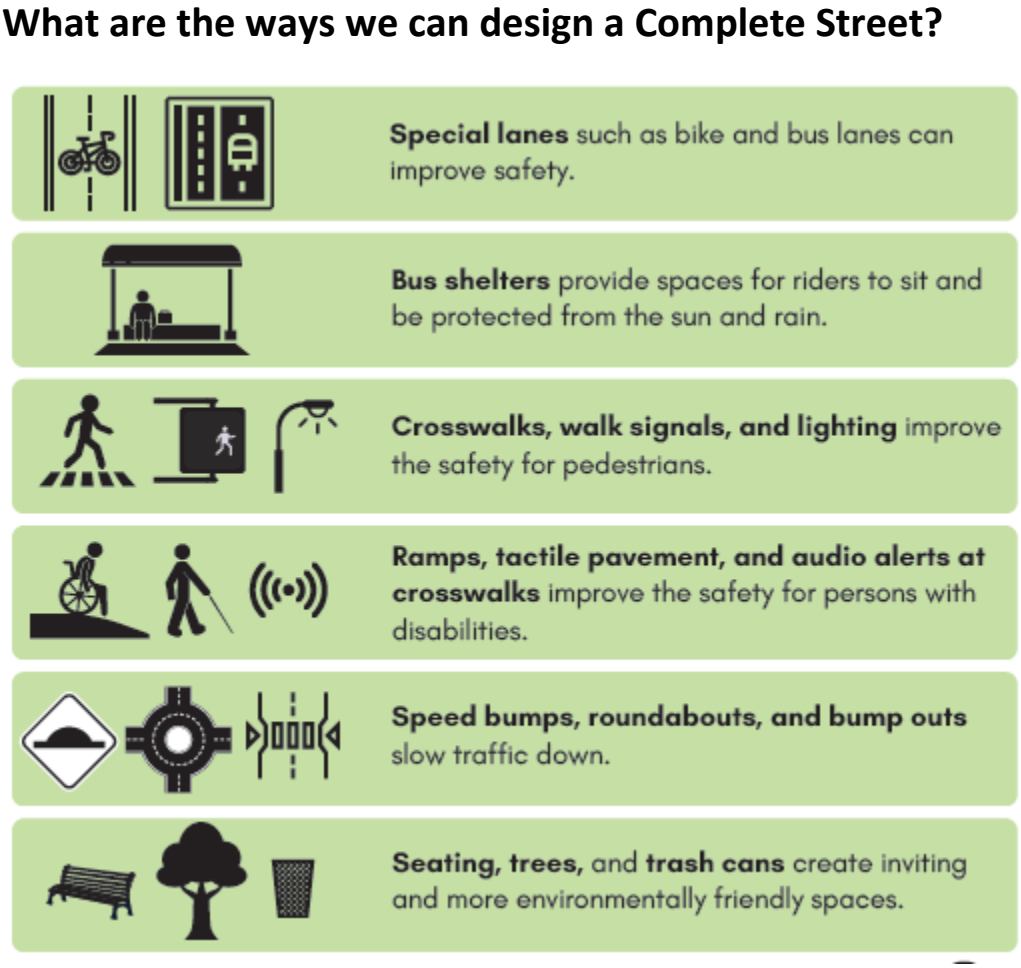

FIGURE 2: COMPLETE STREETS DESIGN IDEAS

Students have the option to complete this activity either manually with paper, pencil, ruler, and measuring tape or digitally using computers. Detailed instructions and resources for both methods are provided in the "Transportation Engineering Activities" booklet, which is appended to this report. This booklet contains all the essential information for educators and students to effectively execute the activity, regardless of the chosen method.

3.0 ACTIVITY 2: CURB DESIGN: CREATE AN ENJOYABLE DOWNTOWN

Downtown areas often experience congestion arising from various modes of transportation competing for limited space. Balancing the need for efficient mobility with creating an enjoyable urban experience poses a significant challenge. This activity aims to cultivate a livable downtown environment by developing a curb management plan for a bustling street.

Participants will engage in the following learning objectives:

- Application of Engineering Design Process: Utilizing the engineering design process to address real-world challenges inherent in curb management.
- Critical Evaluation of Design Solutions: Critically evaluate the effectiveness of the design solution in meeting the diverse needs of downtown users.
- Efficient Space Utilization: Determining strategies to utilize limited space efficiently while alleviating congestion.

Activity steps include:

1. Understanding Curb Spaces: Participants will gain insights into the value of curb space and the varied needs of stakeholders. Examples include delivery truck drivers, bus drivers, individuals with disabilities, customers, store owners, taxi/rideshare drivers, and food truck owners, each requiring specific accommodations.
2. Designing the Curb Management Plan: Participants develop a comprehensive plan considering the requirements of different user groups while optimizing space utilization. An example plan template guides participants in selecting functions, assigning user permissions, and describing space utilization.
3. Revenue Planning: Participants devise a revenue plan to generate $60/day from curb spaces, considering factors such as construction, road maintenance, meter upkeep, and labor costs. The importance of non-revenue-generating features, such as benches, in city vibrancy is emphasized.
4. Marketing Plan Development: Participants craft a marketing plan highlighting the features of their curb management plan to garner support from the Department of Transportation. Emphasis is placed on creating an enjoyable downtown while ensuring sufficient revenue generation.
5. Evaluation and Voting: Plans are evaluated based on criteria such as effectiveness in enhancing downtown experience and revenue generation. Participants score their own plan and two others, subsequently voting for the most promising proposal.

Through this activity, participants develop practical skills in urban planning and curb management while gaining a deeper understanding of the complexities involved in creating vibrant and accessible downtown environments. Again, detailed instructions and resources for

working on this activity are provided in the "Transportation Engineering Activities" booklet, which is appended to this report.

4.0 ACTIVITY 3: DESIGN AN APP FOR SAFER SCHOOL ZONES

In today's digital age, mobile applications serve various purposes, from navigation to communication. This activity focuses on using the power of app technology to enhance safety in school zones. Participants will learn how to design the user interface of an effective app prototype aimed at promoting safer driving behaviors and reducing speeding incidents near schools.

Throughout this activity, participants will achieve the following learning objectives:

- Utilizing the Engineering Design Process: Participants will apply the engineering design process to conceptualize and develop a paper user interface prototype of a school zone safety app.
- Critical Evaluation of Design Solutions: Participants will assess the effectiveness of their app design in meeting specified safety needs and addressing potential user challenges.
- Understanding App Functionality: Participants will explore how apps detect location using GPS and employ geofencing technology to trigger alerts in designated areas.

Activity steps include:

1. Learning about Apps: Participants will examine various apps they have used in the past and discuss their functionalities, particularly regarding location awareness and alert systems. An introductory video on GPS technology will provide insights into location detection in smartphone apps.
2. Brainstorming Solutions: Participants will identify the target users and functionalities of their school zone safety app. Considerations include user experience, advertisement strategies, and mitigation of distractions while driving.
3. Designing the App: Participants will create sketches of the app screens, illustrating user navigation and features. Features such as customizable settings and geofenced alert areas will be described.
4. Evaluating the App: Participants will evaluate their app prototype based on predefined criteria, such as its ability to warn drivers, minimize distractions, cater to diverse user needs, and ease of use. Peer evaluation of other app prototypes will also be conducted.
5. Improving the App: Participants will brainstorm ways to enhance their app based on feedback received during evaluation. Considerations may include refining user interface elements, enhancing functionality, or addressing potential usability issues.

Through this activity, participants will develop a deeper understanding of the role of technology in promoting safety and explore innovative solutions to address real-world challenges in school zones. Additionally, they will gain practical experience in app design and evaluation, fostering

critical thinking and problem-solving skills. As with the previous two activities, detailed activity related instructions and resources including templates are provided in the "Transportation Engineering Activities" booklet, attached to this report.

5.0 EVALUATION

The activities developed underwent piloting at two week-long virtual summer camps aimed at rising 8th, 9th, and 10th graders, organized by the South Carolina Governor's School for Science and Mathematics (GSSM). Throughout and following the camp sessions, students were requested to complete evaluation forms, documenting their perspectives on the overall camp experience and specifically the transportation engineering activities. This section provides a comprehensive overview of the camps' structure, content, and student feedback analysis.

5.1 Pilot Program

As part of its annual programming, GSSM organizes residential and virtual summer camps. The transportation activities' lesson plans developed through this project were integrated into two one-week long virtual summer camps targeting rising 8th, 9th, and 10th graders. Participants in these camps were students residing in South Carolina, engaging remotely via computers. The structured camp schedule facilitated a dynamic learning environment, balancing online instruction with hands-on activities conducted individually or in groups. The following section provides an overview of the camp structure and expectations.

Camp Schedule:

Monday – Thursday:

8:45 a.m. – 9:00 a.m.: Technology Check-In

9:00 a.m. – 10:00 a.m.: Online Instruction

10:00 a.m. –12:00 p.m.: Offline Worktime & Virtual Office Hours

12:00 p.m. – 1:00 p.m.: Lunch/Open Time

1:00 p.m. – 2:00 p.m.: Online Instruction

2:00 p.m. – 3:30 p.m.: Offline Worktime & Virtual Office Hours

Friday:

2:00 p.m.: Final Project Showcase (Concludes camp)

Camp Expectations:

Online Instruction: Included lectures, introduction of topics, Kahoot quizzes, group discussions, presentations, and other activities.

Offline Worktime & Virtual Office Hours: Featured short lectures, individual activities, group discussions/activities, submission of work, and check-ins with professor if needed.

Camp Content Overview:

Introduction: Covered what is engineering, the roles of engineers, types of engineering, essential skills, and the design process.

Civil Engineering: Activities involved building bridges using various materials and addressing transportation challenges.

Mechanical Engineering: Featured guest lectures and a hands-on project to design and build a collision safety device.

Electrical and Computer Engineering: Participants engaged in designing a school zone safety application, exploring concepts in electrical and computer engineering.

Closing: Discussed other types of engineering, sustainability, making a difference in the world, and concluded with a discussion session.

Summary: Participants reflected on their learning experiences and prepared for project presentations, summarizing key takeaways and reinforcing their understanding of engineering principles.

Overall, the pilot activities successfully engaged participants in interactive learning experiences, combining online instruction with hands-on activities and collaborative projects. The structured schedule and diverse range of topics covered provided participants with a comprehensive introduction to engineering concepts and fostered enthusiasm for further exploration in the field.

5.2 Student Feedback

During the camp, students were asked to provide feedback on the transportation related activities. They answered several questions before and after participating in the transportation activities.

The pre- and post-surveys were designed to evaluate students' knowledge and skills in transportation and generally STEM fields before and after attending the camp. The surveys contained both multiple-choice and open-ended questions. Some of the survey questions are listed below:

1. How knowledgeable are you about STEM?

Options: "Not knowledgeable", "Slightly knowledgeable", "Moderately knowledgeable", "Very knowledgeable"

2. How would you rate your ability to work well in teams?"
   Options: "Poor", "Average", "Good", "Excellent"
3. Rate your knowledge about the following fields on a scale from "Not knowledgeable" to "Very knowledgeable."
   a. STEM
   b. Engineering
   c. Planning/Urban Design
   d. Transportation
   e. Human Behavior
4. Rate your abilities in the following on a scale from "Poor" to "Excellent."
   a. Analyze and Solve Problems
   b. Work Well in Teams
   c. Present and Communicate Ideas
   d. Apply What You've Learned
   e. Learn New Concepts Quickly
5. What interests you the most about transportation?
6. What are your expectations from this camp?

At the post survey, questions focused on students' knowledge and skills after participating in the camp. Questions added to the pre-survey included:

1. How would you rate the camp overall?
2. Would you recommend this camp to a friend?
3. The camp instructors provided clear instructions.
4. List three new things you learned this week.
5. What was your favorite part of the camp?
6. What would you improve about the camp?

Table 1 shows summary results for some of the pre- and post-survey questions.

TABLE 1: SAMPLE ANSWERS FROM THE PRE- AND POST-SURVEYS

Question	Pre-Survey Responses	Post-Survey Responses
What interests you most about transportation?	"Safety and speed of transportation" "Design and sustainability of transportation systems" "Innovation in urban mobility"	"Smart transportation systems and their efficiency" "Sustainability and urban mobility concepts" "Bridge design and curb management principles"

What are your expectations from this camp?	"To learn about innovative transportation systems" "To improve my knowledge in sustainable engineering" "To gain teamwork and presentation skills"	"Learn about transportation engineering in detail" "Improve my understanding of transportation systems" "Collaborate effectively in team projects"
List three new things you learned this week	*Not Applicable (Post-Survey Only)*	"Civil engineering - curb designs" "Sustainability principles" "Complete streets concepts"
What was your favorite part of the camp?	*Not Applicable (Post-Survey Only)*	"Complete streets activities" "Bridge design workshop" "Working on team projects and Kahoots" "Learning about smart transportation systems and their efficiency"

Overall, participants highlighted the camp's hands-on activities, collaborative environment, and knowledgeable instructors as significant positive aspects.

In conclusion, the pre- and post-surveys aimed to capture changes in knowledge and abilities in various STEM fields through a mix of multiple-choice and open-ended questions. The analysis shows that participants improved their knowledge and skills in areas like teamwork and applying concepts while expressing high satisfaction with the camp.

6.0 CONCLUSIONS/SUMMARY

The K-12 curriculum developed in this project aims to successfully introduce middle and high school students to the field of transportation engineering. It aims to fill gaps in existing educational materials by offering three comprehensive lessons and hands-on activities focused on the following emerging transportation engineering topics:

1. Complete Streets Design: Emphasizing inclusive street design for all users.
2. Curb Management Strategies: Creating vibrant downtown areas through effective curb management.
3. Transportation Technology Applications: Developing innovative solutions using app-based technology.

Each lesson incorporated engaging, real-life activities and aligned with the Next Generation Science Standards (NGSS), ensuring a comprehensive educational experience.

Students who participated in the pilot summer camps provided overwhelmingly positive feedback through pre- and post-surveys. The pre- and post-survey comparisons showed

significant improvements in students' knowledge and skills in key transportation areas. Some students reported gaining a deeper understanding of the diverse career opportunities in transportation engineering and others that the curriculum enhanced their interest in pursuing further education in STEM and transportation-related fields.

The summer camps were structured to balance online instruction with hands-on activities, ensuring dynamic learning. The pilot program's successful outcomes have paved the way for a summer camp fully dedicated on transportation engineering in June 2024.

The overall positive feedback indicates that the curriculum is effective in inspiring and educating the next generation of transportation professionals. By emphasizing practical skills and career opportunities, it aims to cultivate a passion for transportation engineering while addressing the evolving needs of the industry.

7.0 ATTACHMENTS

As part of this project, a "Transportation Engineering Activities" booklet was developed including detailed instructions and resources for the three activities aforementioned. The booklet is attached to this report.

8.0 ADDITONAL RESOURCES

Additional resources can be found at the STRIDE Center website at https://stride.ce.ufl.edu/k-12-workforce-development/resources-for-educators/

9.0 REFERENCE LIST

1. National Academies of Sciences, Engineering, and Medicine (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press. Link to paper.
2. Next Generation Science Standards. (2023). NGSS Standards. Next Generation Science Standards. Retrieved from Link to paper
3. Cypress Engineering and Information Technology. (2024). What is Transportation Engineering? Retrieved from Link to paper
4. Welle B., Li, W., Adriazola-Steil C., King, R., Obelheiro M., Sarmiento, C., and Liu Q. (2015). Cities Safer by Design: Guidance and Examples to Promote Traffic Safety through Urban and Street Design. World Resources Institute. Retrieved from Link to paper
5. Subudhi, S. (2023). What is Transportation Engineering? Indeed. Retrieved from Link to paper