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Service Learning Through Extracurricular Activities: Development and Implementation of a Transportation Engineering Learning Module

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Service Learning Through Extracurricular Outreach Activities:
Development and Implementation
of a Transportation Engineering Learning Module

An Undergraduate Honors College Thesis

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ABSTRACT

This project developed an easy to implement, low-cost learning module. The module has students compare and contrast the challenges of gathering comprehensive and quality transportation data through advanced technologies and traditional approaches while introducing traffic engineering topics like traffic signal timing. The modules target middle through high school students and first and second year undergraduate engineering students. The learning modules introduce transportation engineering using an engaging open-source computer simulation game adapted by students at the University of Arkansas, as part of a capstone project. The activities in the learning modules require off-the shelf, low-cost computer hardware, making it easy for educators or professionals to implement as in-class exercises or outreach activities.

This paper presents (1) a complete lesson plan that details the concepts (e.g. transportation planning, traffic sensing, and data analysis), (2) a description of the technology including equipment needed to implement the learning activity, and (3) recommendations for tailoring the modules to different age groups. As a result, three different implementations were analyzed and compared to decide the areas of improvement for future applications of this learning module. The overall goal of this interdisciplinary learning module is to increase students' awareness of the diverse nature of the engineering profession. A primary intended application of the learning module is to provide an outreach activity for active transportation professionals to use for "teach-ins" or other STEM outreach community events.

Keywords: Educational outreach, STEM, Service-Learning, Traffic Data Collection, Traffic Signalization

INTRODUCTION

The transportation field is interdisciplinary, involving planners, civil engineers, computer scientists, electrical engineers, industrial engineers, economists, and more. Service learning is one way to better link course content with students' motivation to study a subject while introducing non-traditional and interdisciplinary transportation engineering concepts. While it can be a challenge for instructors to develop and implement an entire course centered on service learning, it is possible to inject service learning through non-classroom activities such as student-group sponsored outreach. Student chapters such as the American Society of Civil Engineers (ASCE) and the Institute of Transportation Engineers (ITE), for example, engage with the local communities through K-12 classroom visits, university sponsored engineering summer camps, and university "open-house" weekends. These events not only positively impact the community, but allow engineering students to hone their communication skills, apply classroom learning to develop outreach activity content, and appeal to their desire to produce broader impacts on their local community. Moreover, the use of active learning strategies in outreach programs is essential to address student motivations learning and for choosing a future career.

In this project, a series of learning modules were developed to introduce students to traffic signal timing and traffic data collection. The broader goals of this project were to:

(1) raise awareness of the diversity of the transportation profession by implementing outreach activities with school-age students,
(2) provide a service-learning opportunity for college level students by having them develop and implement the outreach learning modules, and
(3) create an easy to implement, low-cost educational "kit" for transportation professionals to use for community and classroom outreach events.

The expected outcome of the learning modules is for students to be able to describe the role of a transportation engineer and list examples of traffic engineering projects, apply the scientific method to compare fixed and manual traffic signal control types, and identify how traffic variables such as traffic volumes, speeds, network size, and signal timing influence system performance.

In 2017, two dynamic and new lesson plans were developed with the focus of introducing the concepts of traffic signal timing and traffic data collection. These were implemented at the University of Arkansas (UA) STEM Outreach Day hosted by the Power Optimization of Electro-Thermal Systems (POETS) Center and the 2017 and 2018 Maritime Transportation Research and Education Center (MarTREC) GirlTREC camp. Each of these university-sponsor camps were targeted at middle and high school girls with the goal of attracting diverse students to study engineering. The learning modules described in this paper were tailored to the skills and interest level of the different age groups. For example, during the GirlTREC summer camp, middle school students performed a live role play of a signalized intersection as part of their hands-on experience. While at the POETS camp, the high school girls participated in computer simulations of traffic control scenarios. After the activities, students presented their findings and were asked to reflect more generally on the importance of transportation, traffic engineering, and how these professions impact society.

The modules use an open-source computer simulation game created by the University of Minnesota, developed under a grant of NSF. This simulation game was later revised and improved by students at the University of Arkansas, as part of a Capstone senior design project. These games were developed for K-12 curricula to be used by middle and high school teachers. In this project, however, the focus was on how undergraduate engineering students can use these same tools to design and implement their own outreach activities and the impacts that would have on engineering student success.

Since one of the broader goals of this project is to provide to professional organizations such as the Arkansas Institute of Transportation Engineers (ARITE), a product to use as outreach, the learning modules were developed as 'build kits'. The kits contain all the necessary materials to execute the leaning activity. The lesson plans guide instructors and students on general concepts about transportation engineering, apply strategies of the scientific method through the use of computer based simulator, and analyze and present results from the simulations to extract meaningful insights. Even through transportation professionals want to share the joys of their profession through outreach, professionals struggle to provide interactive and engaging workshops due to the significant time commitment it would take to develop a lesson plan. The main advantage of having ready-to implement lesson plans is that it allows them to engage with local communities through K-12 classroom visits, university sponsored engineering summer camps, etc. The transportation field is interdisciplinary, therefore, motivating students to pursue transportations careers through the use of educational outreach that include these interdisciplinary fields is becoming a challenge among professionals who want to educate and recruit young engineers who will be able to work in interdisciplinary teams and handle big data. The implementation of these outreach activities will allow students to hone communication skills and increase not only class retention but young students' awareness of transportation engineering as a field of study.

This paper presents (1) a complete lesson plan that details the concepts (e.g. transportation planning, traffic sensing, and data analysis) and equipment needed to implement the learning activity in the section titled '**Methods**', (2) examples of three implementations of the learning modules in the section titled '**Results**', (3) methods to use the same lesson plan concept for transit topics in the section titled '**Extensions**', and (4) conclusions summarizing the lessons learned and steps forward in the section titled '**Conclusions**'. As a benefit, this activity uses off-the shelf, low-cost computer hardware, making it easy for educators or professional chapters to implement.

BACKGROUND

As the transportation engineering practice evolves to require more interdisciplinary skills, it is important for STEM programs to integrate cross-disciplinary learning activities into their curriculum. Moreover, the emergence of "big data" across many engineering disciplines has led to the need for training and education related to the collection, management, and analysis of "big data". While it can be challenging for instructors and professionals to develop and implement an entire educational outreach activity, it is possible to inject service learning through extracurricular activities such as student-group sponsored outreach.

Previous research suggests the development of outreach activities in the STEM area and/or transportation as a tool to increase student's awareness of the transportation engineering field. Hernandez and Ritchie (2016) suggest that unique service-learning courses are a good model for creating projects that reinforce the students' motivation to persist in the degree programs (1). They provide a list of possible service-learning activities that would give hands-on experience related to data-driven project evaluations. Although there is evidence that hands-on experience increases class retention, there are limited publically-available educational tools for educators to implement. This implies that educators have to develop these tools ad hoc, which can be time-consuming and likely means that these important topics will go uncovered.

As a means to facilitate introduction of transportation concepts into K-12 classrooms, researchers at the University of Minnesota (UM) developed a suite of open-source, computer-based educational games and lesson plans on various transportation topics (2). In this project, we focus on transitioning the tools developed for classroom teachers to tools for professional organizations like ARITE and college-level programs/groups like ASCE or the student ITE chapter. In doing this, we infuse the idea of service-learning into educational outreach since college-level students design and implement the outreach programs.

Several institutions have developed learning modules related to a variety of traffic engineering and/or transportation engineering topics (Table 1). The learning lab at The Ohio State University focuses on transit concepts while the program at Georgia Tech centered on inclusive transportation designs for the disabled. The simulation game called 'Gridlock Buster' developed by Chen-Fu Liao, was cited as a positive tool to promote student excitement and comprehension about traffic engineering concepts (2). Including these interactive tools as active-learning strategies to engage students creates increased engagement from the students and introduced students to state-of-the-practice technologies in transportation engineering, i.e. simulation (2)..

Table 1 Learning Module and Lab Example

Theme	Learning Module and Lab Examples
Campus Transit Lab (The Ohio State Univ.)	Development of an operating transit bus system into a living lab
Georgia Transportation Institute (Ga. Tech)	'Wheelchairs and Supershoes' learning module about measurements in transportation engineering
Center for Transportation Studies (University of Minnesota)	'Gridlock Buster' traffic control game based on tools and concepts used by traffic control engineers.

Developing lesson plans about transportation engineering for younger students, e.g. pre-driving age, can be challenging, especially when technical concepts like signal timing are being introduced. The American Society of Engineering Education (ASEE) has developed practices and guidelines for K-12 engineering education through various engineering related outreach activities (3, 4). These guidelines were used in this project to design learning modules for different age groups, taking special consideration of the divide between pre-driving age and driving-age students in terms of the introduction of transportation engineering concepts and selection of age-appropriate active learning strategies.

Retention, or the ability of students to persist in engineering programs, has been found to be linked to students' understandings of how their intended profession will impact and improve society. Considering that service learning provides an important link between classroom concepts and community engagement, it has been shown to improve retention (1). Moreover, first and second year engineering students are at a point in their educational careers when they are choosing between different engineering professions. Thus, it is important to introduce students early-on to the impacts that transportation engineers have on society. The National Resource Center for the First Year Experience and Students in Transition at the University of South Carolina studies the impact and outcomes that service learning for high school students has on retaining students in their first year of college (5). They observe correlation between the ability to overcome problems and issues faced by first-year students and participation in high-school service-learning programs (5).

In relation to the impacts of STEM outreach on younger students, the National Math and Science Initiatives (NMSI) found that early introduction to STEM is a critical component of later career decisions (6). NMSI suggests that the current percent of students ready for college level STEM courses, 45% of 2011 U.S High school graduates are ready for college level math and 30%

are ready for college level science, could be improved through earlier STEM topic introductions (6). NMSI also mentions that only 38% of the students who opt to start a STEM career actually finished one. This last number clearly reflects the low class retention in STEM areas. As a solution, implementing more service-learning activities in the curriculum can potentially lead to an increase in class retention and also allow students to develop additional hard and soft skill (7).

METHODS

This study presents a method to create service learning activity implemented as an extracurricular activity for student-group sponsored outreach. Each outreach activity has three basic modules. In the first module, participants are introduced to basic signal timing concepts. Then, depending on the age-group (middle or high school) online games and simulation or role play are used to experiment with signal timing concepts. Lastly, after running simulation experiments, the students prepare and present their findings to the group. Following are the steps followed to develop these service learning activities and the lesson learned for each of the implementations.

This thesis project provides an example of a series of outreach activities developed at the University of Arkansas. These lesson plans have been designed in response to current recommendations found in the K-12 and first-year engineering outreach literature review. These lesson plans were developed to be a ready-to-use learning module for STEM outreach summer camps. Early findings indicate a positive impact on students understanding of mathematics and science, especially transportation engineering technical concepts. The outreach materials are oriented towards the emerging trends in the transportation engineering profession mostly created based on technology available to most students such as computers, tablets, etc. These learning module make use of free, online computer games.

In the summer of 2017, the team conducted two outreach activities. One for high school girls (the POETS STEM day camp) and one for middle school girls (the MarTREC GirlTREC camp). These outreach activities were part of two different week-long summer camps. For both age groups, the students were introduced to the basics of traffic signal timing but through two different approaches (Figure 1). The high school students participated in an online computer simulation to introduce the basics of signal control (Figure 1a). For younger students (Figure 1b), instead of using the computer based simulator, students experiment with delay and signal timing through live-role play. Role-play involved girls acting as “trucks” by walking around with their hands on each other’s shoulders, girls acting as “cars”, a girl operating a small, toy traffic light, and girls as “data collectors” sitting down with stop watches and clipboards.

To make this simulation successful, extra care was taken in separating and explaining roles using the set of instruction listed on the instructor’s guide, which is included in Appendix A. In both modules, students were able to identify strategies to effectively test and interpret different signal timing schemes (for example, manual vs. pre-timed control).

(a) High school students interacting with computer simulation

(b) Middle school students actively participating in live role-play

Figure 1 Examples of student activities during learning module implementation

The goals for the outreach activities developed are: (1) Increase awareness of careers in transportation and traffic engineering, (2) Introduce basics of traffic signal control, which includes: queuing diagrams, cycle length and phases, etc., and most importantly the use low cost (or free), readily accessible tools and technologies.

The outreach activity is composed three basic components (Figure 2). In the first module, we introduce the students to basic signal timing concepts. Then, depending on the group (middle or high school) we use online games and simulation or role play to experiment with signal timing concepts and delay. Lastly, after running simulation experiments, the students prepare and present their findings to the group.

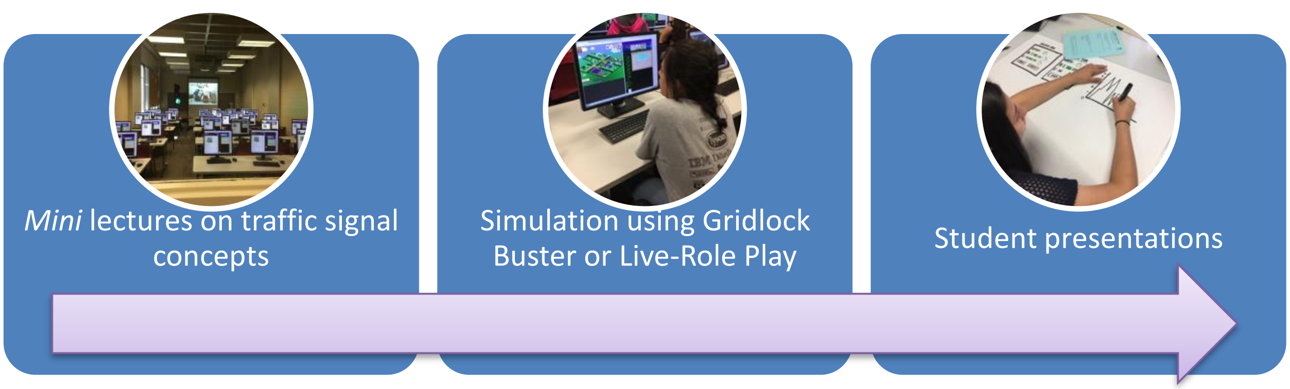

Figure 2 Overview of lesson plan structure

RESULTS

This section details each of the three implemented learning models including a description of each implementation, a summary of the positive outcomes, and suggestions for improvements. Appendix A, B, and C contain the complete learning module materials. The appendices contain the instructor's guide for Implementation 1 and 2 (note that Implementation 3 is a replica of

Implementation 1). The guide describes the dynamics of the workshop from the instructor's point of view, showing when and how to implement the activities. The students' handout needed for each of the workshops are also included in the appendices. All the complementary materials can be also found in the faculty advisor's website at https://sites.uark.edu/sarahvh/service/

Implementation 1: POETS STEM Outreach Day

Description

This first implementation took place at the '2017 POETS STEM Girls Day' program organized by the University of Arkansas as part of their spring semester camp. Students from local high schools visited during a week-long camp. Approximately 16 students participated and 5 helpers were needed for this first implementation. First, mini lectures were completely based on traffic signal concept where students were introduced to key concepts and definitions including gridlock, signal phases, queue, etc. Guided notes handouts were given to the students to follow along with the mini lectures. Second, students played the computer game, Gridlock Buster. The simulator was selected based on the accessibility to all ages, students, even young students, who have a very intuitive understanding of computer games. Once we establish a basic understanding of how signal timing, delay, and coordination are related, students were assigned to groups of two and asked to perform experiments by changing from manual to pre-timed control and varying the level of traffic using a second computer simulation game created by the UM called MyTrafficKontrol. This game allows students to set signal phase (green times) times for each approach and then produce queue and delay diagrams. They can then compare under which traffic loading and signal timing they were able to produce the least delay. A handout with guided questions was given to the students to help them design their experiments and create a presentation (Table 2). Fourth, and last, student groups presented their findings to the larger group by preparing posters with flip chart paper and markers (Figure 3).

Table 2 Experiment using the scientific method

Scientific Method	Question Asked
Hypothesis	What will you test? In a sentence, state the idea you will test
Experiment Procedure	List the variables you will use and the steps you will follow to test your hypothesis
Observations and Results	Look at the queuing graphs that you saved from your experiment. Write down any observations based on the queuing graphs
Conclusion	Did the experiment confirm your hypothesis? State what you can conclude from the experiment

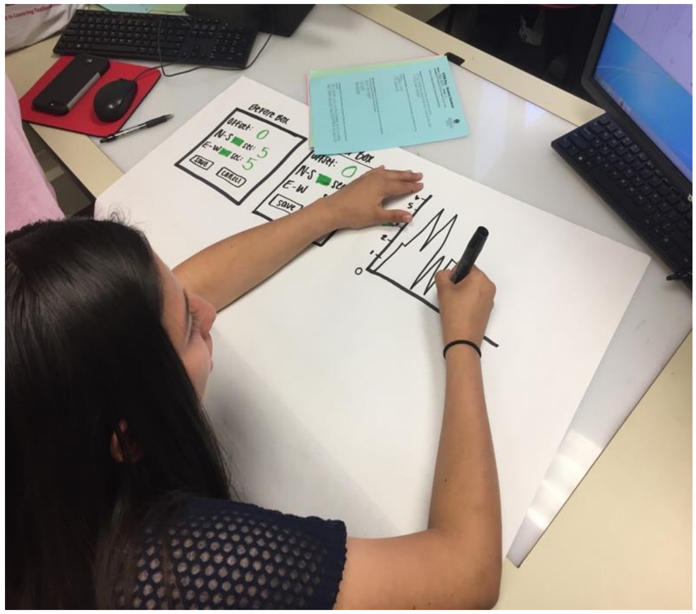

Figure 3 Students prepare final presentations

Positive Outcomes
Overall, the program went smoothly and time allocated for each activity was found to be adequate. The use of the mini lecture to introduce key terms helped with the later presentations.Another observation from this workshop was that the students' were very engaged in the preparation and delivery of their final presentations at the end of the workshop. The students were provided guidance on what questions to address in their presentation and we believe this helped them scope out their presentation. The students prepared a diverse set of presentations including written paragraphs, bulleted notes, and illustrative graphs.

Improvements Needed
For this implementation, the main need was to develop a better simulator capable of producing a simpler user interface and also to create an easier to install software (there were some glitches in the installation due to security settings of the game that had become outdated). Feedback from classroom teachers present at the event indicated that the games would not be able to be installed on a classroom computer. Therefore, we decided to update the games so that they can be installed more readily, and in addition, we chose to edit some of the logic involved in the games as well as some of the output formats of the queue diagrams. We worked with the UA Computer Science Department to create a Senior Design Capstone project to recreate the game by added corrected logic, improved graphic design, and new reporting features.

Implementation 2: 2017 MarTREC GirlTREC

Description
The second implementation took place at the '2017 MarTREC GirlTREC' program organized by the University of Arkansas as part of their summer camp event where students from middle school visited during a week-long camp. Approximately 25 students participated and 4 helpers were needed for this second implementation. In this implementation, the transferability of the technologies previously developed were tested and as a result, a similar program as the one used in 'Implementation 1' was carried out. However, for younger audiences, instead of using the

computer based simulator, students experimented with delay and signal timing through live simulation (Figure 6). In these photos you can see the organized chaos of our simulation. One can see, there is a small traffic light, some girls acting as longer "trucks" by walking around with their hands on each other's shoulders, girls acting as "car", and girls sitting down collecting data with stop watches acting as "data collectors". To make this simulation successful, we were very careful in separating and explaining roles. These roles were used as detailed in Table 3.

Figure 4 Live role play for middle school students

Table 3 Live Queue Simulation Role

Assigned Role	Main Responsibility
Traffic Controller: Control traffic using the signal	1.Press the phase change button on the top of the traffic signal. 2.Try to minimize the queues.
Police Officer: Make sure no one is speeding	1. Watch the 'cars' and 'trucks'. 2. Stop vehicles that are 'speeding'
Phase Monitor: Keep track of signal cycle changes	*Participant 1:* Start the stopwatch when the light turns RED and keep the stopwatch running until the end of the experiment. *Participant 2*: Write down this time on the data collection handout.
Queue Counter: write down the time the vehicle enters and exits the queue	*Participant 1:* Start the stopwatch when the light turns RED and keep the stopwatch running until the end of the experiment. *Participant 2:* Write down the times vehicles enter and exit the queue
Cars: single drivers, pass through the intersection and obey the signals	1.Go to your assigned approach 2.Follow pattern listed in your envelope (i.e. A→B→ C→ D, which indicated the intersection to enter as a route) 3. Obey the traffic signals and speed limit
Trucks: Pairs of two, stay together through the intersection and obey the signals	1.Find your partner 2. Go to your assigned approach. Follow the pattern listed in your envelope (i.e. A→B→ C→ D, which indicated the intersection to enter as a route). 4. Obey the traffic signals and speed limit.

Positive Outcomes

The fact that this implementation followed the same format as the first implementation but with a twist about the form of delivering the information improvement the outcomes in certain areas. Introducing concepts of traffic engineering in a live-role play allowed for more retention of some of the key concepts like pre-timed and manual traffic control. Making sure students received all the information about roles and purpose of the exercise before executing the live role play helped contain some of the chaos. As an extra resource, a layout of the scenario expected for this implementation was also included in the power point presentation (Figure 5). This was provided with the idea of helping students visualize the scenario and it also helped them locate their position in the live-role play.

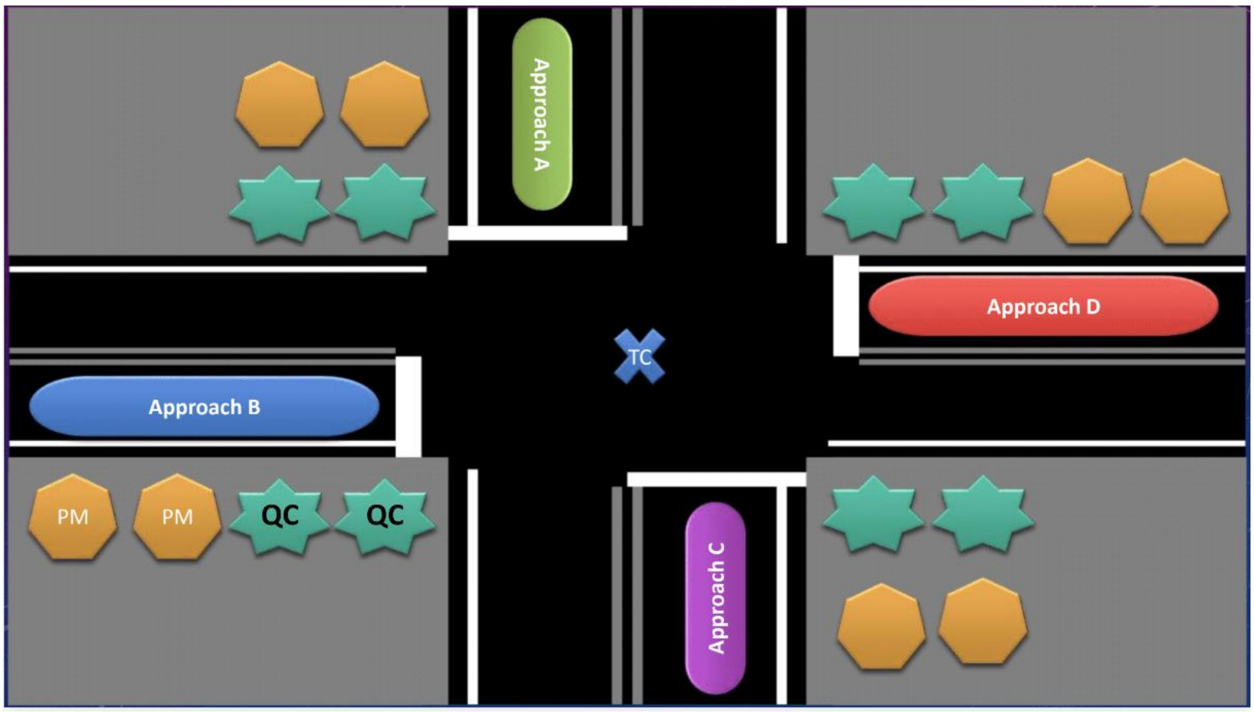

Figure 5 Layout for the live-role play in the second implementation

Improvements Needed

The main improvement for this implementation was found to be the most challenging task for working with younger students, which was the data analysis. There was an overestimation on the level of math and skills to analyze this type of data. The time allotted for this exercise was limited at one hour which was not sufficient to explain the main mathematical concepts need to have students graph and analyze the results.

Another major difficulty found was the use of the stopwatches during data collection as well as the design of the handout used for data collection. The method of timing and recoding the data in the handout confused many students and during the mini-lecture, there was not dedicated time to explain the proper use of the tools. Therefore, for future implementation additional description of the data collection tools used during the live-role play simulation needs to be provided or this portion of the exercise needs to be removed entirely.

Implementation 3: 2018 MarTREC GirlTREC

Description

The third implementation took place at the '2018 MarTREC GirlTREC' program organized by the University of Arkansas as part of their summer camp event where students from middle school visited during a week-long camp. Approximately 15 students participated and 3 helpers were needed for this third implementation. In this implementation, the same mini-lecture was used to introduce students from middle school to general concepts of transportation engineering. Taking into consideration the lessons learned during Implementation 1, the newly designed Transit Trouble game was used (Figure 6). The game had a more user-friendly interface among other added features. Taking into consideration the lessons learned during Implementation 2, the live-role play was simplified.

(a) Instructions and layout of level 1 (Manual Time Control)

(b) Instructions and layout of level 7 (Fixed Time Control)

Figure 6 Layout of the simulator interface for 'Transit Trouble'

Positive Outcomes

The main improvement in this implementation was observed in the level of data collected by students during the live role play. Changes to the roles assigned in the live-role play were made. Instead of having all the live-role play roles described on Table 3, the queue counter and phase monitors were not included. However, there was still the need to analyze data. Therefore, a new role was included, 'Traffic monitor". This role consisted of recording observations related to traffic patterns, queue lengths, and other observations about flows.

Another main improvement was the use of the new simulator Transit Trouble. This simulator clearly introduces students to the concept of manual traffic control (levels 1-4) and pre-timed traffic control (levels 5-8), which basically consists on signal phase times that are pre-set based on historic traffic patterns. The main idea is to demonstrate the difference between pre-timed and manual control and understand the applications of both control types.

Improvements Needed

The amount of time allotted for each activity in the lesson plan was definitely a factor that could be improved in the future. Considering the level of understanding on some of the topics to be addressed during the mini lectures and the time it is needed to explain and try out the simulations are the areas of focus for improvement in the amount of time to spend. It is recommended to try out the complete lesson plan with a group of colleagues first, before implementing it to students. This will give a general idea on the sections where time could be an issue and with that improve it.

EXTENSIONS

The same process of developing the lesson plans was used to create a learning module for transit and include more interdisciplinary approaches. The objectives of this learning module are: (1) to introduce students to transit planning concepts, (2) to develop students' computer programming skills, (3) to apply learned concepts to design better transit routes (which also teach students how to navigate transit.), and (4) to engage students in active learning using low cost (or free) technologies. The transit lesson plan (Figure 7) uses the same three stage approach of mini-lectures in key concepts, interaction through sensor design, and experimentation and data analysis through field data collection. Concept for the sensor and field data collection center on recording MAC-addresses broadcast from travelers' phones or computers and then matching MAC-addresses across different transit stops so that trip origins and destinations can be recorded.

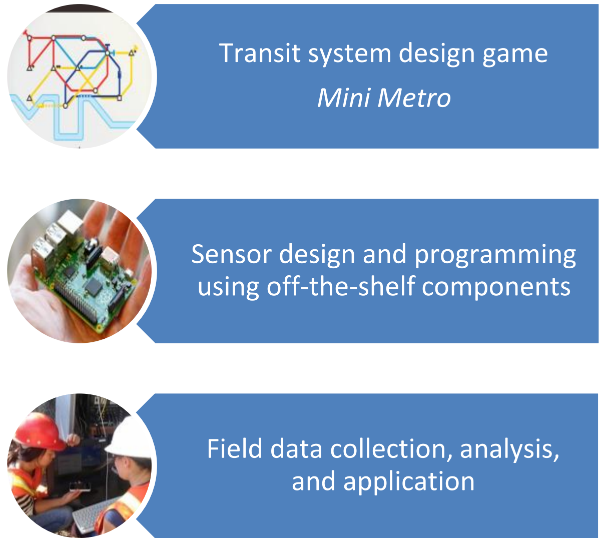

Figure 7 Overview of learning module for transit

The students will collect transit boarding/alighting data at bus stops and analyze transit trip origin-destination locations and times and transit wait times. As part of the future work, this lesson plan will be implemented to for different age groups so that the methods and materials can be further refined.

CONCLUSIONS

This project describes the development and implementation of a series of learning modules for three different education levels (i.e. middle school, K-12, and First-Year engineering students) to introduce concepts in transportation engineering. Each learning module follows the same three stage approach: min-lectures, active learning through computer games or live simulation, and debrief through group presentation and questioning. The development of these lesson plans is based on the need to introduce young students to the concept of engineering. Three implementations of the lesson plans were carried out in 2017 and 2018 in different university-sponsor camps. Through these programs, we gauged student interest and learning from each of the activities by observations and anecdotal comments from the students.

Our observations indicate that these learning modules had a positive impact on the participating students and increased their understanding of technical terms and concepts. As part of the future work, a pre- and post-survey will be developed to quantitatively measure student learning outcomes and the overall "success" of the learning modules. This will be an essential tool to evaluate the knowledge that students have before performing the workshop and after.

We have also given careful attention throughout the development of our lesson plans to limitations such as age of the participants, size of the group, and technology available. The main benefit of the lesson plans is that it encourages and increases the participation of university faculty members and college students in K-12 outreach. Originally, our outreach efforts were restricted to our own (the authors') efforts to support local school districts. However, our idea was expanded to senior engineering students via a form of service-learning which involved a senior capstone project to revamp the computer games used in the learning modules. Future work will expand the service learning to ITE and ASCE student chapter organizations by working with these groups to further develop and implement the lesson plans. Service learning has several benefits that can be realized using this lesson plan concept: opportunities to apply classroom learning to develop outreach activities, increase student retention, increase student communication skills, and raise awareness of the diversity of the transportation profession and its impacts on society.

An added benefit of the lesson plans is that professional organizations can use these plans for outreach and community engagement. Use of existing plans like these would save time and cost and potentially encourage more professional chapters like ARITE to engage with future engineers. All the materials can be also found in the faculty advisor's website at https://sites.uark.edu/sarahvh/service/

ACKNOWLEDGEMENT

The authors thank the University of Arkansas for allowing the implementation of the lesson plans that lead to this paper and the students that participated in the outreach camps. We are especially grateful to MarTREC for allowing us to host a session during the GirlTREC camps in 2017 and 2018. We strongly believe that reinforcing classroom knowledge is essential to improve students' retnetion. We hope that this paper helps others implement service-learning activities into their currilum.

AUTHOR CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: study conception and design: S. Hernandez; data gathering and processing: K. Diaz; analysis and interpretation of results: K. Diaz, and S. Hernandez; draft manuscript preparation: K. Diaz and S. Hernandez. All authors reviewed the results and approved the final version of the manuscript.

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APPENDIX A: MATERIAL FOR IMPLEMENTATION 1

A.1 Instructor's Guide for Implementation 1

STEM Day
Location: Bell Engineering CVEG computer Lab (2nd Floor).
Duration: 60 minutes.
Time: 04/08/2017 (9:30AM - 3:15PM)

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

✏ *Overview*:

High school students will be introduced to transportation planning. The students will work with computer based game to compare controlling traffic manually versus using the fixed-time controls.

✏ *Learning Outcomes:*

This workshop was designed with the objective of letting high school students interact with traffic control systems and have a better understanding of concepts related to the area of transportation engineering

Outcomes	*How will the students achieve this outcome?*
#1: Students will be able to have a **different perspective** about transit planning and the careers in transportation engineering such as traffic engineering, and city and regional planning.	PowerPoint mini-lecture will be presented to the students.
#2: Students will **develop** engineering skills, **experience** the thinking process and creativity of engineering, and **work on teams**.	Students will follow the scientific method to conduct an experiment, interacting with a simulator simultaneously.
#3: **Identify** how variables such as traffic volumes, speeds, network size, and signal timing influence the system performance.	Interacting with a simulator and analyzing the graphs for fixed and manual time system.

✏ *Supplies Needed:*

Quantity	*Item Name*	*Specifics:*
30	STEM Day – Student Handout	Each student will be supplied with a handout.
20	Computers with Internet connection and Java enabled for each student or small group of students	One computer per student.
1	Flip chart paper set	For the instructor. Remember to get some markers.
20+	Pencils with erasers	Provide one per student
45	Index Cards	To help writing down definitions
6+	Color Permanent Markers	

✐ Room Configuration:

How will the room be set up?
- Organize the computers by groups of three or four depending on attendance. Try to spread the groups throughout the classroom. Not only in one section of the lab. - Two students will be observers and one will be game controller. Role exchange may occur during the workshop. - Print 30 handout for the students and place 4 copies per computer. - Verify that the software is installed and ready to use in all computers.

✐ Preparation:

Check List:	What needs to be done in advance?
	Load Power-Point with the mini-lecture prepared.
	Print and place the "STEM Day – Students Handout" with pencils and index cards in the computers that will be used.
	Test the Traffic Control simulation on each student machine.

✐ Workshop Schedule:

Stage	*Begin Time*	*End Time*	*Total time*
1. Welcome and introduction to the workshop.			15 min.

NARRATIVE:

Slide 1:" Transportation Engineering: Traffic Control Simulator"

Welcome everyone to transportation Engineering workshop! We are so excited to work with all of you and get to know each other. Today we have only few minutes for this workshop but we have a lot to accomplish. That being said, let's just get started.

Slide 2:" Who We Are?"

Every member of the group can introduce themselves. Name, country, what do you do?

Slide 3: "What Are We Going to Do Today?"

- First, we will give you a little introduction about what transportation engineering is and what types of careers are offered in this field.
- Then, you will learn essential concepts about signal timing that will help you with the simulator we have prepared for you today.
- After that, working in group, you will have a chance to play with the traffic control simulator.
- And of course! the most important part is to have a lot of fun while we are learning.

Slide 4: "How do you get to the movie theater?"

This slide is hided. Tempting Ice Breaker Activity

(ask around the classroom, expect one answer from every girl). This activity should be no

more than 5 minutes).

Everyone should say their name and their favorite mode of transportation. For example, my name is __________ and my favorite mode of transportation is_________.

Slide 5: "What is transportation Engineering?"

Today we are here to learn a little more about transportation engineering. But first let's think about what the word transportation and what it really means for us in our daily life…

For example, imagine if there are no busses, cars, airplanes, trains, or bikes in the world and you really need to get to the concert of your favorite artist and your house is 20 miles apart from it. How would you get there? Would you walk?... I wouldn't. That why I recognize the important value of transportation modes in my daily life. These modes can take me from one location to another and you can see them available almost everywhere. Even though walking is one of these modes of transportation. It sometimes can make people's life more difficult. To make it easier transportation engineers come up with ideas and innovations that facilitate our daily life and probably we don't even think about it we just use them. SO, how can we define transportation engineering?

Slide 6: "Transportation Engineering"

- Transportation planning is a sub-discipline of civil engineering.
- Transportation Engineers focus on designing new transportation systems and infrastructures, including
    - Highways
    - Airports
    - Trains
    - Bridges, etc.
- They do this by **analyzing** data, **identifying** problems, and **solving** them with innovative solutions.

Slide 7: "Video"

Slide 8: "Careers Options in Transportation"

Some career options found on transportation engineering are:

- Be a City Traffic Engineer.
- Traffic Engineer Consultant.
- Design Freeways, Mass transit, Rail or street.
- Design traffic signal.
- Design High Intelligent Transportation.
- Invent New Innovative Products/ Devices.
- Run your own Engineering Business.
- MANY MORE!!

Slide 9: "Which intersection is "better"?

Now that we have a better idea of what transportation engineering is and what careers are offered. Let's see what you think… Unconsciously, you have been a passive observer of many of the problems that transportation engineers have identified. One example are the figures shown. Imagine you are exhausted from a school, all the knowledge you have received in the day and when you get to the first signal light you find something like the figure on the left. That will make you so sad. Obviously the one on the left seems to be more congested. Meanwhile, the one on the right presents a smoother flow of cars. How do you think would be the technical term to use in this case?

Technically, transportation engineers call this phenomenon GRIDLOCK, this is a situation of very severe traffic congestion. Transportation engineers develop strategies that are then tested in a simulator like the one you will have a chance to interact with today.

Slide 10,11,12: "Gridlock buster!"

- Did you know that Transportation Engineers use simulator that are just similar to this one to develop more efficient signal timing pattern and produce a better traffic flow?
- You will have **5 minutes** to interact with the simulator.

Open the Gridlock Buster for students, let them play! Remember there are prizes for students who get to level 4.

How does it feel to be a transportation engineer?
What are the things that made it difficult.?
What made you decide to change from red to green?

2. *Activity 1:* Introduction to Signal Timing and Traffic Control Simulator			20 min

Slide 13: Figure
Talk about simulators for about 1-2 minutes.

Slide 14: "Introduction to Signal Timing & Traffic Control".

Now that you have practiced being a traffic signal operator, lets apply the scientific method to improve how we can control traffic signals. Our goal as transportation engineers is to move people as safely and efficiently as possible!

Slide 15: "Activity 1: Simulator Interaction (Follow Handout)"

[Distribute Handout-] The handout has instructions that go along with the next activity.

Stop me if you are not following along with me or if you have any question in general. In this activity we will explore how to improve signal timing.

Slide 16: "Important Terms for Traffic Signal Timing".

During this activity, some technical words will be mentioned and it is important to us that you follow along. On the first page of your handout, there is some space for you to write down the definition of these terms.

- **Delay** – When a vehicle has to stop at a red light, the driver experiences delay.
- **Queue** – a line of vehicles waiting at a red light.
- **Efficiency** – How well a traffic signal operates to reduce the amount of traffic delay.
- **Performance Index** - queue length + amount of time delayed.

Slide 17: "Objectives of Traffic Simulator".

The objectives of this simulator are:

- Traffic engineers use computer simulations to test new traffic signal timing.

- We follow the scientific method to conduct an experiment → which signal timing is the most efficient?
- Compare graphs generated by traffic patterns to select the most efficient traffic signal timing

Slide 18: "What are you responsible for in this simulation?"

- Working in groups, students will use the traffic control simulator to complete several experiments to determine how to create a consistent traffic pattern.
- Make sure to:
  - Keep the graphs produced as you advance in the simulator.
  - Write down in the handout provided the score, performance index (PI), and ending of queuing length.
  -

Slide 19: "How the Simulator Works?"

- *First, you will choose the simulation settings. In your handout we have provided the initial network settings.*

Slide 20:" Run the simulation"

Explain how it pause and play and where to get the graph from.

Slide 21: "Now it's your turn."

You should all have the simulator already open in your computers, if anybody needs help finding the simulator please let us know. You will have a couple minutes to interact with the traffic control simulation. You can choose the settings you like. *(GIVE THEM 2-3 MINUTES TO INTERACT WITH THE SIMULATOR).*

Slide 22:" Record your Results"

As the pictures in the right show, you will have the game and then you can hit pause and select graph. Then in the new window you select: Queue(veh) and then OK. That should display the graph from the model you just created with the simulator.

Slide 23: "Queue Statistics"

- After you interact with the simulator you will generate a statistical graph that represent the Queue Length (number of vehicle in queue) and the x-axis is the simulation time when the queue happens.
- Read blue box.
- Explain the representation of the lines. Questions?

Slide 24: "Group Discussion"

- What is the longest queue you created?
- How many cycles are there in your simulation?
- How consistent is your pattern?
- Compare your graph to the 1 x 1 Fixed Time graph shown below. This graph is also included in Page 4. Which is more consistent? Why?

Slide 25: "Explanation"

- You just performed Manual Traffic control! - Transition to fixed time control.			
3. *Activity 2:* Variable Experiment Using the Scientific Method			20 min
Slide 26: "Activity 2: The most Efficient Signal". *Slide 27: "What can you change to improve the signal timing?* *Slide 28,29, 30,31: "Show the students how the scientific method applies to our workshop".* *Slide 31: "Student Presentations"* *Slide 32: "Thank you slide! End of workshop."*			

A.2 Student Handout A for Implementation 1

STEM Day – Student Handout

Name:____________________ **Group:** _____
Location: Bell Engineering CVEG computer Lab (2nd Floor).

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Signal Timing:

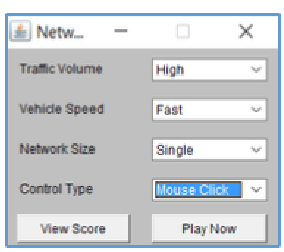
The goal of any traffic system is **to maintain** a safe, consistent, predictable and efficient environment for drivers. Traffic Control lets you act as a traffic engineer by letting you control signals and traffic flow at multiple intersections. We'll use this simulation to test a hypothesis and in doing so, develop a better understanding about how traffic engineers use the scientific process to solve every-day problems.

- Important to know:
  - Delay:
  - Queue:
  - Efficiency:
  - Performance Index (PI):

Activity 1: Manual Control

1. *Open* the simulation following the instructor's indications. You will have a couple minutes to interact with the traffic control simulation.

2. *Restart* the simulation with the following settings:



STEM Day – Student Handout

Name:____________________ **Group:** _____
Location: Bell Engineering CVEG computer Lab (2nd Floor).

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

1. Complete the table:

Graph No.	Score	PI	Queue Length

2. *Answer the questions*:

   a. What is the longest queue you created?

   b. How many cycles are there in your simulation? (a cycle is a peak and valley)

   c. How consistent is your pattern?

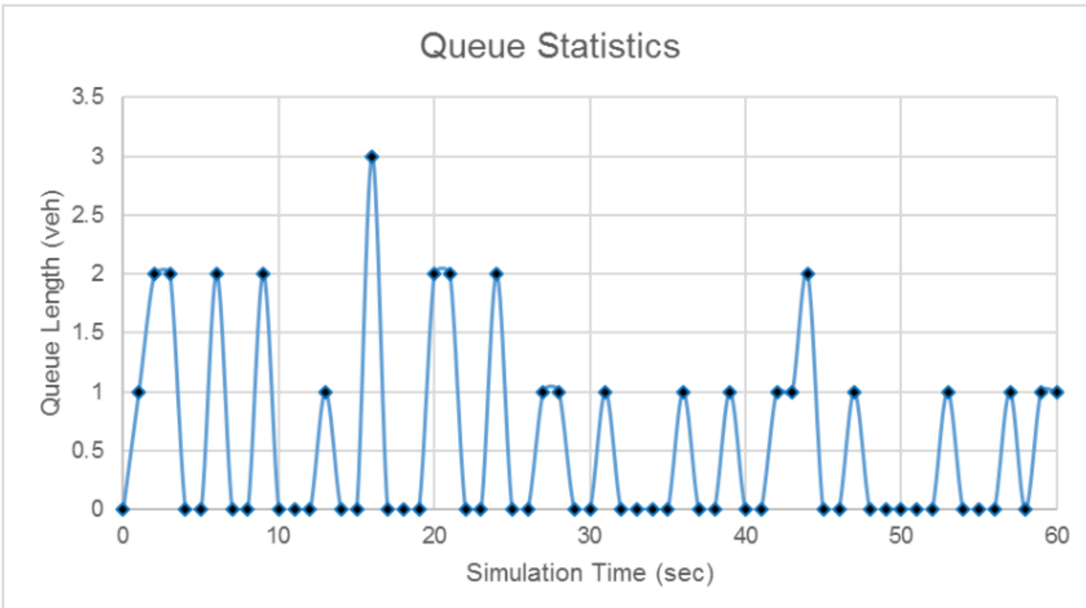
   d. Compare your graph to the 1 x 1 Fixed Time graph shown below. Make comments on how your graph compares to this graph.

STEM Day – Student Handout

Name:____________________ **Group:** _____

Location: Bell Engineering CVEG computer Lab (2nd Floor).

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING



3

A.3 Student Handout B for Implementation 1

STEM Day – Student Handout

Name:___________________ **Group:** _____

Location: Bell Engineering CVEG computer Lab (2nd Floor).

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COLLEGE OF ENGINEERING

Activity 2: Variable Experiment Using the Scientific Method

Hypothesis: What will you test? In a sentence, state the idea you will test:

Experiment Procedure: List the variables you will use and the steps you will follow to test your hypothesis:

Observations and Results: Look at the queuing graphs that you saved from your experiment. Write down any observations based on the queuing graph:

Conclusion: Did the experiment confirm your hypothesis? State what you can conclude from the experiment:

APPENDIX B: MATERIAL FOR IMPLEMENTATION 2

B.1 Instructor's Guide for Implementation 2

GirlTREC Day

Location: Bell Engineering INEG Faust computer Lab (4nd Floor) and CVEG student lounge.

Duration: 2 hours.

Time: 9:30AM -11:30AM

✐ Overview:

Fifth and sixth grade students will be introduced to traffic engineering. The students will work with a live role-play game and a computer based game to compare traffic control scenarios: manual vs. fixed-time.

✐ Learning Outcomes:

The objective of this workshop is to introduce students to traffic engineering and signal timing. The lesson is designed for fifth and sixth grade students. The specific learning outcomes and aligned activities are as follows:

Outcomes (Students will be able to…)	*How will the students achieve this outcome?*
#1: **Describe** the role of a transportation engineer and list examples of traffic engineering projects.	PowerPoint mini-lecture and career **video**
#2: **Apply** the scientific method to compare fixed and manual traffic signal control types.	Students will use **computer simulation** and **live role-play** to conduct an experiment by gathering data, creating hypotheses, analyzing data to support or refute the hypothesis, and draw valid conclusions.
#3: **Identify** how variables such as traffic volumes, speeds, network size, and signal timing influence system performance.	Graph data from the role-play to analyze fixed and manual time traffic control systems. Students will prepare presentations on their experiments to share with the class.

✐ Supplies Needed:

Quantity	*Item Name*	*Specifics:*
45	STEM Day – Student Handout	Each student will be supplied with a handout.
40	Computers with Internet connection and Java enabled for each student or small group of students	One computer per student.
1	Flip chart paper set	For the instructor. Remember to get some markers.
40	Pencils with erasers	Provide one per student
TBA	Clipboards	Provide one per timer student

20+	Color Permanent Markers	At least 3 packs of 12 markers
1	Theo Klein Traffic Light	
3	Duct Tape for road design	Yellow, white, black https://www.amazon.com/dp/B00SNWI80G?psc=1
4	Road looking floor coverings	
TBA	Stopwatches	
TBA	Safety Vest	For operation staff
1	Flip Chart Pads (Gridded Paper)	Link to Amazon: https://www.amazon.com/Easel-Tabletop-Sheets-Inches-79250/dp/B003ZSH750/ref=sr_1_6?s=office-products&ie=UTF8&qid=1497386081&sr=1-6&keywords=gridded+paper
	RaceTrack Floor Runner	https://www.amazon.com/dp/B00SNWI80G?psc=1

✐ ***Room Configuration:***

How will the room be set up?
- Two rooms are needed: computer lab and role-play room - Depending on attendance, one computer will be used by student. If groups need to be formed, try to spread them throughout the classroom. Not only in one section of the lab. - Print 45 handout for the students. The will be multiple handouts in this workshop, make sure they are all printed. - Verify that the software is installed and ready to use in all computers. This workshop only needs to have access to Gridlock Buster. Details further in the instructor guide. - The role-play room will be cleared of desks and chairs. The intersection will be drawn out using the floor coverings, duct tape, and other materials. 'X' marks will be drawn at the branch of each leg of the intersection to show the data collectors where to stand.

✐ ***Preparation:***

Check List:	What needs to be done in advance (Activity 1)?
	Load Power-Point with the mini-lecture prepared.
	Load and test the "Gridlock Buster" simulator in every computer.

Check List:	What needs to be done in advance for the demonstration (Activity 2)?
	Create an intersection using the building supplement materials (traffic light toy, duct tape for lane separations, etc).
	Have the safety vest for the operator staff for the selected students.
	Have ready the clipboards and the envelops with the data sheet and supplement material needed to start annotation the data collected.

✏ Workshop Schedule:

Stage	Begin Time	End Time	Total time
4. Welcome and introduction to the workshop.			15 min.

NARRATIVE:

Slide 1:" Transportation Engineering: Traffic Control Simulator"

Welcome everyone to the Transportation Engineering workshop! We are so excited to work with all of you and to introduce you to the fascinating world of traffic engineering. Today we have only a couple hours to share but we have a lot to accomplish so let's get started!

Slide 2:" Who We Are?"

Every member of the group can introduce themselves. Name, country, what attracted you to transportation engineering, what do you study/research?

Slide 3: "What Are We Going to Do Today?"

- First, we will give you a little introduction about what transportation engineering is and what types of careers are offered in this field.
- Then, you will learn essential concepts about traffic signal timing that will help you with the simulator we have prepared for you today.
- After that, we will do a LIVE queuing demonstration where you will collect traffic data and analyze it to improve the traffic system.
- And of course! the most important part is to have a lot of fun and ask a lot of questions during the workshop.

Slide 4: "How do you get to the movie theater?"

Tempting Ice Breaker Activity

(ask around the classroom, expect one answer from every girl). This activity should be no more than 5 minutes).

If previous ice breaker activity is not selected, this is another option: Everyone should say their name and their favorite mode of transportation. For example, my name is __________ and my favorite mode of transportation is_________.

Slide 5: "What is transportation Engineering?"

Today we are here to learn a little more about transportation engineering. But first let's think about what the word transportation and what it really means for us in our daily life…

For example, imagine if there are no busses, cars, airplanes, trains, or bikes in the world and you really need to get to the concert of your favorite artist and your house is 20 miles apart from it. How would you get there? Would you walk?... I wouldn't. That's why I recognize the important value of transportation modes in my daily life. These modes can take me from one location to another and you can see them available almost everywhere. Even though walking is one of these modes of transportation. It sometimes can make people's life more difficult. To make it easier transportation engineers come up with ideas and innovations that facilitate our daily life and probably we don't even think about it we just use them. SO, how can we define transportation engineering?

Slide 5 (Continued): "Transportation Engineering"

- Transportation engineering is a sub-discipline of civil engineering.
- Transportation engineers focus on designing and managing transportation systems and infrastructure, including
  - Highways
  - Airports
  - Trains
  - Traffic signals
  - Bus schedules
  - Bridges, etc.
- They do this by **collecting** travel data, **analyzing** data, **identifying** problems, and **solving** them with innovative solutions.

Slide 6: "Video"

Present the video about the history of transportation (1:44 minutes long)

Slide 7: "Careers Options in Transportation"

Some career options found on transportation engineering are:

- City Traffic Engineer
- Traffic engineer consultant work for a company that services many cities.
- Design freeways, streets, highways, sidewalks, bike lanes.
- Plan and manage transit systems like rail or subways
- Manage and control traffic signals
- Design Intelligent Transportation Systems (ITS)
- Plan for self-driving cars
- Plan inclusive transportation systems- kids, elderly, working adults, handicapped, etc.

5. *Activity 1:* Gridlock Concept and Simulator			15 min

Slide 8: "Which intersection is "better"?

Now that we have a better idea of what transportation engineering is and what careers are offered. Let's see what you think… Unconsciously, you have been a passive observer of many of the problems that transportation engineers have identified. One example are the figures shown. Imagine you are exhausted from a school, all the knowledge you have received in the day and when you get to the first signal light you find something like the figure on the left. That will make you so sad. Obviously the one on the left seems to be more congested. Meanwhile, the one on the right presents a smoother flow of cars. How do you think would be the technical term to use in this case?

Technically, transportation engineers call this phenomenon GRIDLOCK, this is a situation of very severe traffic congestion. Transportation engineers develop strategies to improve these situations. The strategies include better timing of the traffic signals or encouraging alternate forms of transportation like riding the bus or using a bike.

Slide 9: Explain simulation concept

Have you ever thought about how traffic engineers test what works and what doesn't when it comes to traffic signal timing or new roadway designs? [Ask students to think about the question on the slide: How do traffic engineers test what traffic signal timing will work well?]

Most likely students will say try out different timings. The instructor should point out that it would be risky to try out different timings because it could make things worse or unsafe. Instead we use simulation. Simulation: replicate the real work with computer models.

In the next activity, you will use simulation to explore traffic control.

Slide 10,11,12: Activity 1: "Gridlock buster!"

- Did you know that Transportation Engineers use simulator that are just similar to this one to develop more efficient signal timing pattern and produce a better traffic flow?
- You will have **5 minutes** to interact with the simulator.

Instruct the students to open Gridlock buster (it should be already open for them just to use), let them play! Remember there are prizes for students who get to level 4.

After 5 minutes of them playing ask them the following question:

How does it feel to be a transportation engineer?
What are the things that made it difficult.?
What made you decide to change from red to green?

Now is time for the prizes, ask:

Who got to level 4? Students on this level get prizes

Talk about simulators for about 1-2 minutes. It could be mentioned that actual traffic engineers use simulators to observe the flow of traffic in the streets of a city. They make sure the cars are moving and that traffic jam is reduced as well as controlling the activity or behavior of drivers and users of the service.

6. *INTRO* Signal Timing and Traffic Control			20 min

Slide 13: "Introduction to Signal Timing & Traffic Control".

Now that you have practiced being a traffic signal operator, lets apply the scientific method to improve how we can control traffic signals. Our goal as transportation engineers is to move people as safely and efficiently as possible!

Slide 14: "Activity 2: Simulator Interaction (Follow Handout)"

[Distribute Handout - PINK] The handout has instructions that go along with the next activity.

Stop me if you are not following along with me or if you have any question in general. In this activity we will explore how to improve signal timing.

Slide 15-19: "Important Terms for Traffic Signal Timing".

During this activity, some technical words will be mentioned and it is important to us that you follow along. On the first page of your handout, there is some space for you to write down the definition of these terms.

- **Phase** - traffic signals operate in phases: red and green.
- **Cycle** – is the completion of both a red and green phase.
- **Delay** – the amount of time a vehicle is stopped at a red light.
- **Queue** – a line of vehicles waiting at a red light.
- **Efficiency** – the ability of the traffic signal timing plan to reduce delay and minimize the queue

- **Dissipation time –** amount of time it takes for queue of stopped vehicles to go through the intersection
- **Service time -** time when a vehicle crosses through the intersection

S.18:

- **What is a queue?**
- In this section, we will learn about queue and how they form. Ask students for example to when you wait in line?
- In general, a queue is a line of people or things waiting to be handled, usually in sequential order stating at the beginning.
- ANALYSIS: What would happen if the rate at which people arrive is greater than the rate at which people leave the queue? Would the queue dissipate faster or slower?
- *The instructor could relate the formation and dissipation of queue to delays. This is another factor that traffic engineer study when designing a signal traffic control. Now students should acknowledge that the rate at which people arrive should be smaller than the time it takes them to dissipate the queue to avoid delays.*
- *Ask students about personal experiences with delays or even waiting on a queue. Questions such as:*

  -When have you waited in line?

  -Did you ever stop to wonder why lines form?

  -Why do you sometimes have to wait in line for a sandwich?

Students should recognize that lines form because supply can't keep up with demand. In terms of traffic that means that if more pedestrians or vehicles arrive than can depart at a given point in time, then queue (lines) begin to form.

S.19:

- **How do traffic signals operate?**
- Describe that in engineering terms, traffic signals operate in phases: red and green. A cycle is the completion of both a red and green phase. For purposes of simplicity and clarity, the yellow phase will be considered part of the red phase in this discussion.
- **Recognize that queues form when traffic flow is stopped by a traffic signal.** The challenge for engineers is to time the signals in a way that ensures all vehicles are **serviced** (can cross the intersection) before end of the green phase.

Slide 20: "Let's Review Graphs"

We are eventually going to perform a real life traffic simulation. When we do this, we will
(1) decide how long we want each phase to be
(2) collect data on the queue, dissipation time, and service time using the phase timing
(3) analyze the data to determine if the signal is efficient

*Slide 21: "*Fill in the Blanks"

- To graph a point one draws a dot at the coordinates that corresponds to the ordered pair. It's always a good idea to start at the origin. The x-coordinate tells you have many steps you should take to the right (positive) or left (negative). And the y-coordinate tells you have many steps to move up (positive) or down (negative).

- Show students the basic components of a graph: axis, when is linearly increasing, decreasing, and constant.
- Using the PowerPoint **pointer option** complete the graph given with the help from students. This will help them understand what to do with the points once they have collected the data in the next activity.
- Complete the first two to three coordinates and let the students finish the rest on their handout

Slide 22: "Queue Statistics"

- After the students understand the basics on how to graph, you will show a statistical graph that represent the cycle length vs the delay per cycle.
- Explain the representation of the lines.

7. Activity 2: Queue Demonstration	*60 min*

Slide 23: "Activity 2: Live Queue Simulation"

- Working in groups, students will play the role of a traffic control at an intersection to complete several experiments to determine how to create a consistent traffic pattern.
- We have set up an intersection to scale that will be controlled by students.
- The objectives of this demonstration are:
  - Students will understand how long it takes queue to form and dissipate or clear.
  - We follow the scientific method to conduct an experiment → which signal timing is the most efficient?

Slide 24- 31:" Roles and explanation"

S. 24-25:

- There are 4 directions in which traffic can enter/ exit the intersection.
- In the middle of the intersection, the traffic signal operator will be placed and he will control traffic using the traffic light on display.
- Roles are assigned by enveloped taped under the student's seats. The envelope will contain an assignment to one of the roles (a copy of the slide with the role description) and an assignment to an approach of the intersection. Students who are cars or trucks will also be assigned to an intersection approach for starting out. MUST PREPARE IN ADVANCE.
- At each corner where traffic forms, three volunteers will be placed. Their job is very important in this demonstration because they will gather the necessary data from the formation of queue. These volunteers are a timer and two counters. The traffic counters will be two, one will write down the number of vehicles getting in the queue and the other traffic counter will record the time it takes for each vehicle to dissipate or clear the intersection.

- Students will have in their handout a table that contain the count on the number of vehicles entering and exiting the intersection. This table will help the students later when graphing the cycle produced in the demonstration.

S.26-30:

- **TRAFFIC CONTROLER:** Press the phase change button on the top of the traffic signal. Try to minimize the queues.

- **POLICE OFFICER:** Watch the 'cars' and 'trucks' and stop vehicles that are 'speeding'.
- **TIMER:** The phase timer will start the stopwatch once the light turns RED and keep the stopwatch running until the light turns GREEN. His responsibility is to read the time when the counter indicates that there is a new vehicle in the queue.
- **PHASE MONITOR:** Records the time when the signal changes from red to green and keeps track of the cycle
- **QUEUE COUNTERS:** As the timer for the current time each time a vehicle enters or exits the queue and record the information
    - RED CYCLE: students start recording from time 0 seconds when the light just turned red, then in ascending order they will count the number of vehicles in the queue and the time that the vehicle entered the queue.
    - GREEN CYCLE: students record from the existing number of vehicles in the queue.
- In general, students can perform 3-5 cycles during the demonstration. They will pick the best one among those.
- **TRUCK and CARS:** For trucks, pairs of two, stay together through the intersection and obey the signals. For cars, single drivers, pass through the intersection and obey the signals.

S. 31: Only shows again the distribution of student's roles.

Slide 32: "Manual vs. Fix Traffic Control"

- **Manual traffic control**
- That's the same as what the police do to control a signal after a Razorback baseball game
- However, this is not very efficient…would you like to sit at a traffic signal all day???
- **Fixed Time Control**
- Signal phase times are pre-set based on historic traffic patterns
- Fixed time control can be more efficient if set correctly.

Slide 33: "NOW IT' S YOUR TURN"
Take students to the room where the play will take place (CVEG Lounge).

Slide 34-37: "Prepare and analyze the data" Go back to Faust Lab

- Will work in groups of their assigned intersection approach (from the envelopes).
- Have the students prepare the queuing diagrams from their data collection handouts.
- Combine the data from the Phase Timers and the Queue Counters and record the combined data on the handout.
- Ask the vehicles (cars and trucks) to answer the questions on the handout as well.

*Slide ****: "Fixed Traffic Control. Prepare and analyze the data"*

- If time allows, repeat steps **from slide 33 that takes the students to the room where the play takes place until slide 37.** This time use a fixed traffic control.

Slide 38: "Student Presentations"
Slide 39: "Thank you slide! End of workshop."

B.2 Student Handout A for Implementation 2

GirlTREC – QUEUE COUNTERS

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COLLEGE OF ENGINEERING

Names:____________________ **Approach:** __________

Location: Bell Engineering
Traffic Control Type (circle one): Manual Fixed

You have been given the task of **QUEUE COUNTERS**. Remember that your role is for **Girl 1:** Start the stopwatch when the light turns RED and keep the stopwatch running until the end of the experiment and **Girl 2:** Write down the times vehicles enter and exit the queue.

Position should restart at 1 each

VEHICLE POSITION	ENTER Time (sec)	EXIT Time (sec)	DELAY =(EXIT-ENTER)

B.3 Student Handout B for Implementation 2

GirlTREC – PHASE MONITORS

UNIVERSITY OF ARKANSAS COLLEGE OF ENGINEERING

Names:____________________ **Approach:** _________

Location: Bell Engineering
Traffic Control Type (circle one): Manual Fixed

You have been given the task of **PHASE MONITORS**. Remember that your role is **Girl 1:** Start the stopwatch when the light turns RED and keep the stopwatch running until the end of the experiment and **Girl 2:** Write down this time on the data collection handout.

CYCLE NUMBER	TIME		R/G?	LENGTH OF PHASE
	BEGINING	END		
			R	
			G	
			R	
			G	
			R	
			G	
			R	
			G	
			R	
			G	
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			G	
			R	
			G	
			R	
			G	
			R	
			G	

B.4 Student Handout C for Implementation 2

GirlTREC – COMBINED DATA

Location: Bell Engineering **Approach:** ________
Traffic Control Type (circle one): Manual Fixed

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COLLEGE OF ENGINEERING

Instructions to Estimate the Signal's Efficiency:

- Combine the data from the *Phase Monitors* and *Queue Counters* in the table provided on the back of this page.
- Calculate the DELAY per vehicle and the total delay per cycle.

$$Delay_{(sec)} = (Green\ Time - Red\ Time)$$

- Make a graph of *the Cycle Length (y-axis)* and *Delay (x-axis)* per cycle.

GirlTREC – COMBINED DATA

Location: Bell Engineering

CYCLE NUMBER	QUEUE Vehicles	RED Time (sec)	GREEN Time (sec)	Cycle Length (sec):	DELAY Time (sec)
				Average Cycle Length:	Average Delay:

B.5 Student Handout D for Implementation 2

GirlTREC – COMBINED DATA

Location: Bell Engineering

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COLLEGE OF ENGINEERING

Instructions to Estimate the Average Signal's Efficiency:

- Combine the data from all the approaches in the table provided below.
- Make a graph of *the Average Delay (y-axis)* and *Average Cycle Length y (x-axis)* for all the approaches.

Approach	Average Cycle Length (sec):	Average DELAY (sec):
A		
B		
C		
D		

B.6 Student Handout E for Implementation 2

GirlTREC

Discussion for Cars and Trucks

Group Name:_______________________________

Location: Bell Engineering

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

1. Compare fixed and manual signal timing. Which method seemed more efficient?

2. Under what circumstances do you think fixed or manual timing would be more efficient?

3. Why is it important to consider both trucks and cars when designing signal timing schemes?

4. What are the challenges of designing signal timing schemes when there is more than one connected intersection?

B.7 Student Handout F for Implementation 2

GirlTREC

Discussion for Data Analysts

Group Name:______________________________

Location: Bell Engineering

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

1. What was the longest queue created?

2. How many cycles were in the demonstration? (a cycle is a peak and valley) How does the number of cycles effect the queue length?

3. Compare the data collected for manual and fix traffic control. Determine which type of control was more efficient. State why you think it was more efficient and use your data to support your conclusion.

APPENDIX C: MATERIAL FOR IMPLEMENTATION 3

C.1 Student Handout A for Implementation 3

GirlTREC – Student Handout

Name:________________________________

Location: Bell Engineering

UNIVERSITY OF ARKANSAS COLLEGE OF ENGINEERING

The goal of any traffic system is to maintain a *safe, consistent, predictable* and *efficient* environment for drivers. Follow along with the lecture by writing the word that corresponds to each definition.

Use the following words*: **Efficiency, Timing, Phase, Delay, Cycle, Queue.***

Term	Definition
	The red, green, or yellow 'light' indication.
	The completion of both a red and green phase.
	The amount of time a vehicle is stopped at a red light.
	A line of vehicles waiting at a red light.
	The amount of time, usually seconds, that is dedicated to each phase.
	The ability of the traffic signal timing plan to reduce delay and minimize the queue.

C.2 Student Handout B for Implementation 3

GirlTREC
Discussion for Observers
Location: Bell Engineering

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

1. Were any long queues formed during the simulation?

2. Did delay cause frustration?

3. Did the cars and trucks show different behaviors?

4. What challenges did the signal timing controller have?

C.3 Student Handout C for Implementation 3

GirlTREC – Approach B

Location: Bell Engineering
Traffic Control Type (circle one): Manual

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

Instructions to Estimate the Signal's Efficiency:

- ✐ Calculate the Cycle Length (sec):

$$Cycle\ Length_{(sec)} : (Green\ time + Red\ Time)$$

- ✐ Calculate the DELAY per vehicle and the total delay per cycle.

$$Total\ Delay_{(\mathrm{sec})} = 2.5 * (Queue\ Vehicles) - (Red\ Time)$$

- ✐ Make a graph of *the Cycle Length (y-axis)* and *Delay (x-axis)* per cycle.

GirlTREC – COMBINED DATA

Location: Bell Engineering

CYCLE NUMBER	QUEUE	RED	GREEN	Cycle Length (sec):	DELAY
	Vehicles	Time (sec)	Time (sec)		Time (sec)
1	4	6	5	6+5=11	2.5(4)-6=4
2	2	5	4		
3	3	5	3		
4	6	7	6		
5	3	5	3		
6	2	2	1		
7	4	5	4		
8	3	6	5		
9	4	8	7		
10	3	7	4		
$\text{Average Cycle Length} = \frac{\text{sum of all the cycle lengths}}{\text{Number of cycles}}$ $\text{Average Delay} = \frac{\text{sum of all the delays}}{\text{Number of delays}}$				Average Cycle Length:	Average Delay:

C.4 Student Handout D for Implementation 3

GirlTREC

Discussion for Data Analysts

Group Name:______________________________

Location: Bell Engineering

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

1. What was the longest queue created?

2. How many cycles were in the demonstration? (a cycle is a peak and valley) How does the number of cycles effect the queue length?

3. Compare the data collected for manual and fix traffic control. Determine which type of control was more efficient. State why you think it was more efficient and use your data to support your conclusion.

C.5 Student Handout E for Implementation 3

GirlTREC

Closing Discussion

Group Name:________________________________

Location: Bell Engineering

UNIVERSITY OF ARKANSAS
COLLEGE OF ENGINEERING

1. Compare fixed and manual signal timing. Which method seemed more efficient?

2. Under what circumstances do you think fixed or manual timing would be more efficient?

3. Why is it important to consider both trucks and cars when designing signal timing schemes?

4. What are the challenges of designing signal timing schemes when there is more than one connected intersection?