SOUTHERN PLAINS
TRANSPORTATION CENTER

Technology-Rich Transportation Engineering Projects

Sanjay Tewari, Ph.D.
David Hall, Ph.D.
Marisa Orr, Ph.D.
Norman Pumphrey, Ph.D.
Raghava Kommalapati, Ph.D., P.E., BCEE

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Southern Plains Transportation Center
201 Stephenson Parkway, Suite 4200
The University of Oklahoma
Norman, Oklahoma 73019

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16. ABSTRACT

This project targeted students in junior high school and high school through various workshops, demonstrations, and technical activities. These students were from all kinds of racial backgrounds and came from different parts of Texas, Louisiana and other states. Special focus was on underrepresented minorities in STEM fields and female students. In addition to this, high school teachers involved in STEM courses in and around north Louisiana were invited to a three-day training workshop hosted at Louisiana Tech University. Other major activities of the project were focused on providing freshman engineering students hands-on technology rich projects and expose them to various aspects of civil and transportation/traffic engineering. Upper level civil engineering students were targeted for transportation engineering specific activities and projects. Two three-day workshops were organized specifically to train university faculty involved with engineering students at various levels. One of such workshop was for Louisiana Tech faculty. The participants of this workshop were trained on Arduino based projects as well as several other educational projects that were designed for out-of-classroom type hands-on activities. The other three-day workshop was specifically for external faculty. About 15 faculty involved in various aspects of transportation engineering from 11 different universities were chosen based on their backgrounds. During this workshop the participants learned fundamentals of Arduino programming and different ways it could be included in class/lab activities for interactive and hands-on learning. During this workshop, a symposium on active learning techniques was organized in which participants presented case studies, techniques and interactive projects on promoting active and hands-on learning in Civil and Transportation Engineering.

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APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

Technology-Rich Transportation Engineering Projects

Final Report
April 22, 2016

Sanjay Tewari, Ph.D.
Assistant Professor of Civil Engineering and Construction Engineering Technology
College of Engineering and Science
Louisiana Tech University

David Hall, Ph.D.
Associate Professor of Mechanical Engineering
College of Engineering and Science
Louisiana Tech University

Marisa Orr, Ph.D.
Assistant Professor of Mechanical Engineering
College of Engineering and Science
Louisiana Tech University

Norman Pumphrey, Ph.D.
Associate Professor of Civil Engineering and Construction Engineering Technology
College of Engineering and Science
Louisiana Tech University

and

Raghava Kommalapati, Ph.D., P.E., BCEE
Professor of Civil & Environmental Engineering
Prairie View A&M University

Southern Plains Transportation Center
OU Gallogly College of Engineering
201 Stephenson Pkwy, Suite 4200
Norman, OK 73019

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EXECUTIVE SUMMARY

The SPTC is impacting students and teachers in the region using fun, fact-filled activities and through the development of curricular materials for high school- and college-level students. This project entitled “Technology-Rich Transportation Engineering Projects” focused on two of the three major categories of SPTC focus 1) education, outreach and technology transfer and 2) diversity. This project has resulted in publication of two conference papers. All project related training modules and other information was posted on the project website and is available for dissemination purposes.

Technology-rich interdisciplinary projects were developed to build knowledge of and interest in transportation engineering related careers among students enrolled at various levels (e.g., high school, engineering freshmen and upper-level civil engineering courses). During this project, many outreach and diversity efforts targeted women and underrepresented minorities through various activities held at Louisiana Tech University and Prairie View A&M University. These activities included students from all sections of society. One of these outreach activities was setting up a Transportation Engineering booth on Engineering and Science (E&S) Day at Louisiana Tech University every year during the project period. The E&S Day is attended by more than a thousand high school students from about fifty high schools spread all over northern Louisiana. The project team interacted with the visiting high school students and provided them with background and resources on transportation engineering and exciting career opportunities that are there for them to pursue. The visiting students also participated in a fun activity that simulated various traffic related conditions during such as sharp turns, driving at high speed, super elevations of highways, and role of friction in providing traction. A specific race-track was designed for this specific activity. Other outreach efforts that were part of this project included multiple demonstrations and fun-filled transportation related activities for students from underrepresented minorities. These students were participating in multiple STEM related summer camps hosted at Prairie View A&M University. The demonstrations and interactive hands-on activities were organized each year for the duration of the project.

Twelve high school teachers from North Louisiana were invited to campus to participate in a three-day summer workshop. The workshop provided teachers with the resources, knowledge and training to implement the transportation projects at their schools during the following academic years. Each participating teacher was given a starter kit to implement these projects. The projects covered topics of fundamental high school science and mathematics applied to transportation related issues such as momentum and speed of vehicles, contact surfaces and friction, measuring speed of vehicles and other moving objects using hand-held radar guns, water runoff and effects of ground types and slope, quality of the water run-off, measurement of sound from vehicular traffic on the interstate highway and many other hands-on, fun-filled technical activities. It is expected that inclusion and implementation of these activities in various high school classes will have a long lasting impact on students.

Projects suitable for freshman engineering students were developed and incorporated into Louisiana Tech's first-year engineering experience to attract existing engineering students and underrepresented groups to transportation careers. These projects were technology rich and focused on creating working instrumentation that was used for traffic related observation. Students were exposed to Arduino based programming and electronic hardware that they assembled to achieve various measurements of real-life traffic. These projects opened the gateway to transportation/traffic related technical exposure to the participating students (civil engineering majors as well as non-civil engineering majors). In case of civil majors it is expected that many of these students would end-up having better inclination towards transportation engineering and for that reason will choose transportation related electives in their senior year. This would eventually help them for their careers in this field. The motivation behind these ENGR120 series projects, in case of non-civil engineering major students, was to create awareness of transportation engineering among them and recruit them to civil engineering. It is hoped that if/when it is time for them to transfer to a different major, they will remember fun-filled, hands-on, and technology-rich experience from these projects.

A selected group of Louisiana Tech faculty were invited to attend a three-day summer workshop to help implement these projects at the freshman level. The participants were chosen based on their field of studies and level of interaction with freshman engineering students and had a very diverse academic background. Each participant received training and a customized kit. At the end of the workshop, the faculty participants were asked to provide their feedback in making these projects customizable for various courses and expose freshmen engineering students to many aspects of transportation engineering.

Additional transportation projects for upper-level civil/transportation engineering students at Louisiana Tech University were designed and implemented as a part of this project. The projects included gathering traffic data using commercial traffic camera and video traffic analysis, traffic-speed analysis using handheld radars, and using electronic logic board for designing and controlling traffic lights; and are being continuously used to generate interest among civil engineering students towards transportation field.

The training modules, experiences and lessons learned over the course of the project period were shared with transportation and civil engineering faculty from various universities spread across United States. A three-day workshop titled "Arduino Workshop for Transportation Engineering Educators", was hosted at Louisiana Tech University during the month of July in 2016. The workshop was followed by a symposium on "Active Student Engagement in Civil and Transportation Engineering". Twelve faculty from ten different universities participated in both of the events. The participants were chosen based on their technical background and submitted abstract of their proposed presentation/discussion on active student engagement in civil and transportation engineering. Arduino based projects that were previous developed in this project were used as hands-on training. In addition to training, each participant also received a project implementation kit.

1. Introduction

1.1 Problem Statement

The U. S. is currently facing a shortage of skilled technology workers, and the situation is predicted to decline further in the coming years. According to the U. S. Department of Labor, more than 165 million jobs were available in the year 2014. However, just 163 million people will be in the workforce during that same period. According to Bureau of Labor Statistics *[1]* jobs in transportation related areas have grown more than 10% over last decade. Strong efforts are needed to bridge this gap. Looking ahead into the future at the challenges that will be present in the 21st century, there is a critical need of a diverse and technical workforce. Science, Technology, Engineering and Mathematics (STEM) education has been a focus of conversation for educators and policy makers in recent years because economic development is largely driven technology-rich and technology-enabled products and services *[2]*. There is a need to encourage and promote civil engineering and, specifically in this case, transportation engineering among K-12 students. Non-engineering students and freshman engineering students who have not yet decided their majors need to be introduced to the exciting, modern and hi-tech side of transportation engineering. We can attract more students to this field by capturing their attention with technology, ultimately preparing a larger workforce for the challenges of designing modern transportation systems.

In addition to this gap between supply and demand of a technical workforce, there is a lack of diversity in the transportation workforce in terms of gender and underrepresented minorities *[3]*. If this shortage of technical workforce is to be improved, we must reach out to students who are not aware of the interesting careers and challenges in transportation. Underrepresented groups are the least aware. **A diverse workforce is a better workforce.** Therefore, this project had a component that was focused on reaching out to underrepresented minorities. In addition, high school educators and K-12 students in general need to be exposed to technology-rich and exciting hands-on side of transportation engineering to bring a fundamental change in younger generation's perception of traditional civil and transportation engineering.

1.2. Background

This project was focused on generating interest among K-12, engineering freshman students as well as upper level civil engineering students towards transportation related degrees and careers by exposing them to modern technology oriented projects. In recent decades, the student enrollments in civil engineering and, especially, transportation engineering either have shown little growth or fallen relative to engineering majors which "appear" to be more technology weighted *[4]*. Even after arriving at a university and beginning classes, students are still unaware of the opportunities for interesting careers in transportation engineering. Students either have

a traditional “brick and mortar” perspective of civil engineering or in many cases are not even aware of exciting opportunities that are there for them to pursue in civil and transportation engineering. Widespread educational efforts have sought to generate interest in STEM fields, even for civil and transportation engineering. The U. S. Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) have established various educational initiatives to promote diversity as well as reduce the gap between demand and availability of technical workforce. The National Summer Transportation Institute (NSTI) is one successful example. NSTI remains one of the nation’s premiere transportation-centered educational programs focused on middle and high school students around the country.

Exposing large groups of students to transportation-related projects builds awareness in non-engineering students and promotes technology-rich competence in engineering students. The project developed and implemented transportation projects that are suitable for high school students enrolled in hands-on STEM courses, for all freshmen engineering majors and for upper level civil engineering courses at Louisiana Tech University (LTU). The LTU collaborated with Prairie View A&M University (PVAMU) which has hosted its residential Summer Transportation Institute (STI) program for about 8 years. Under the STI program, underrepresented minority students from high schools in Texas and neighboring states are recruited and invited to participate in fun educational activities to expose them to traditional STEM, civil engineering and transportation related concepts. Additionally, PVAMU regularly host STEM summer camps for minority students of various grades (middle and high school). This project enhanced many of these summer programs by implementing new, technology-rich projects for these students. Over 200 freshman engineering students implemented transportation-related projects at LTU.

1.2.1. Past and Current Efforts

The PI and Co-PIs have significant experience in interacting with students at various levels (high school, freshman, and upper-level civil engineering). The Co-PIs have proven records implementing educational innovations that have been implemented across the country, and they have extensive experience with outreach projects that seek to foster interest among diverse learners.

Dr. Sanjay Tewari (PI) has previously worked at PVAMU, a HBCU institution, as a Senior Research Associate. He assisted with hosting the STI summer residential program in 2012. Dr. Tewari gained valuable personal experience in interacting with high school students and generating interest toward transportation related careers through STEM-related projects.

Dr. David Hall (Co-PI) has extensive experience implementing application-based, hands-on STEM projects at the high school and university levels. He is the primary author and architect of the Living with the Lab freshman experience at LTU. Portland State University and Western New England University have implemented Living with the Lab, and other universities are using significant components of this curriculum. Dr. Hall is the faculty advisor for the Engineering and Science Association, a group that hosts large events for the College of Engineering and Science, including Gumbofest (650 university students), Engineering and Science Day (600 high school students from our region), and Spring Release (600 university students). His role, as academic director of Construction Engineering Technology, Civil Engineering, and Mechanical Engineering gives him a unique perspective that will be useful in implementing the projects proposed here.

Dr. Norm Pumphrey (Co-PI) worked as an Highway Engineer with Federal Highway Administration for several years early in his career before returning to school for his graduate degrees in geotechnical and transportation engineering. As a faculty member, he has taught transportation engineering courses at both the undergraduate and graduate levels, including geometric design, traffic engineering, and pavement design and rehabilitation. He was also heavily involved in teaching freshman engineering courses during the first decade of implementation of the integrated math and engineering program at LTU. During the last 10 years, Dr. Pumphrey has been involved at the University level as Director of Advising and Retention for two years before serving for eight years as the first director of the Bulldog Achievement Resource Center (BARC), where he was responsible for a staff that managed tutoring services, writing assistance, and the first-year seminar which most first-time, full-time students take in the fall quarter. In addition, he served concurrently as the Director of the Division of Basic and Career services, where he managed staff involved with students who had not yet declared a major but needed advising services and other forms of encouragement and assistance. He returned to the College of Engineering and Science in January 2014.

Dr. Marisa Orr has participated in various project related activities and contributed in a positive manner. Dr. Orr was added to the project based on her experience in engineering education. Dr. Orr was working as an assistant professor at Louisiana Tech University for the duration of the project. Currently, she is working as Assistant Professor at Clemson University.

Dr. Raghava Kommalapati (Co-PI) has served as Director of the STI Program since 2007; he served as a coordinator from 2000 to 2006. This program is funded by FHWA and is aimed at exposing high school students from underserved communities to the

field of transportation. About 300 students have completed this program. Dr. Kommalapti is a professor of civil engineering and is the director of an NSF-funded research center (Center for Energy & Environmental Sustainability). This center has developed and executed a number of educational and outreach programs directed towards high school students.

1.3. Objectives

The primary objective of this project was to increase the population of qualified transportation professionals using four sources:

1. General high school students
2. High school students enrolled in hands-on STEM classes
3. Freshman engineering students (those interested in technology-driven fields but unaware possibilities in transportation)
4. Upper-level civil engineering students

The activities to support these objectives are briefly summarized below:

1. **K-12 Outreach for Regular High School Students.** Leverage events already being held at LTU and PVAMU that involve over 1000 K-12 students each year, designing activities to specifically build interest among women and underrepresented minorities. The focus events of outreach activities are listed below:
    a. The Exxon-Mobil Bernard Harris Summer Science Camp at PVAMU for students from traditionally underrepresented minorities (about 50-100 middle school students per year)
    b. Pre College Enrichment Institute Workshop – Minority Introduction to Engineering and Science at PVAMU (about 20-40 high school students per year)
    c. The Roy G. Perry College of Engineering Enhancement Institute at PVAMU (about 25-50 students per year)
    d. Research Experience for High School Students at PVAMU (about 15-30 high school students per year)
    e. Engineering and Science Day at LTU (about 800 high school students per year)

    These activities show students simple yet exciting transportation applications to capture their fascination and create more awareness towards transportation. As an example, as part of this project, students attending Engineering and Science Day at LTU got to see creative and fascinating sides of civil and transportation engineering. This event impact around 800 high school students each year.
2. **High School STEM Educators and Students.** Invite educators from various high schools in SPTC region to a three-day training workshop at LTU. Provide an

opportunity for these teachers to learn hands-on technology-rich activities that could be implemented in their classrooms at various levels. Provide these teachers training and supply kits for them to implement transportation-related projects by interfacing sensors with the Arduino microcontroller platform.

3. **University Faculty Training Workshops for Internal Participants.** Host a three-day workshop for faculty at LTU and PVAMU and provide learning opportunity for faculty to learn and implement transportation projects in the first-year "Living with the Lab" experience. Living with the Lab impacts over 300 first-year engineering students each year.
4. **University Faculty Training Workshops for Internal and External Participants.** Invite university faculty from multiple universities in the SPTC region to be part of a three-day workshop to implement projects (suitable for freshman-level and upper-level civil engineering students) that could be used in courses at their home institutions.
5. **Promotional Materials.** Prepare marketing resources (brochures, other promotional materials) and a website to share projects and instructions with educators everywhere. Distribute brochures at outreach events and to teachers participating in the project workshops. The information, through promotional materials, provides a mechanism to grow the impact of the activities beyond those who directly participate in this project.

Present results, impacts and lessons learned from this project at a national level conference focused on civil and transportation engineering to promote the broader dissemination of the projects developed from this funding.

1.4. Scope

This project covered educational and outreach activities that impacted students at various levels (middle school, high school, engineering freshman and upper level civil engineering). This project also impacted educators involved in active teaching in STEM courses at high school, engineering courses at freshman level, material/mechanics/math courses at lower level engineering, and upper level civil/transportation engineering courses. Most of the project activities took place at partnering institutions (LTU and PVAMU) between August 2014 and September 2016. The promotional material is posted on the project website that is accessible to internet users worldwide.

1.5. Technology Transfer

The focus of the project was reaching out to students from sections of the society at various levels and educators in STEM areas to generate interest in civil and transportation engineering. It was achieved by designing and preparing multiple

technology rich activities that provided students hands on experience and exposed them fun and exciting side of this field. In some cases, the hands-on activities and mini-projects were shared directly students in multiple events. Most of knowledge and technology transfer happened in three organized training workshops. The suitable educators from all over nation were invited and provided with technical training and resources for them to implement these developed mini projects at their respective institutions. One specific symposium focused on active student engagement in civil and transportation/traffic engineering was organized at Louisiana Tech. The participating faculty from about 10 different universities spread nationwide got together and shared their ideas and project with each other. The participants were from Oklahoma University, Texas A&M University, Virginia Tech University, University of Nebraska, Citadel Military College, Seattle University, Texas State University, Texas Tech University, Florida Gulf Coast University, Lafayette College, and Lamar University. Additionally, information of these projects and presentation made during training workshops and symposium were made available online on project website. Additional information on technology transfer on specific activities is provided in the related project activities described in this report.

1.6. Methodology, Tasks, and Chronology of the Project

1.6.1. Methodology and Tasks

Designing and implementing project-driven courses in STEM fundamentals is the hallmark of the Integrated STEM Education Research Center (ISERC) at Louisiana Tech University. Through prior NSF, NASA and U.S. Department of Education funding, Louisiana Tech has an established record of engaging high schools with exciting STEM curricula. The curricula developed includes weekend workshops focusing on engineering and science fundamentals, summer camps for students and faculty interested in cyber sciences, and a robotics-centered high school physics curriculum. In all cases, relationships are built with teachers through professional development. These established relationships with teachers in the region, which includes buy-in from principals and superintendents, provide a foundation for SPTC educational outreach.

At the college level, Louisiana Tech's first-year engineering experience provides relevant, project-focused education for over 500 students each year. Our six semester-hour, three-course sequence, called "Living with the Lab," boosts experiential learning through student ownership of inexpensive laboratory equipment. Each student purchases an Arduino microcontroller ($30), hardware components to interface with the Arduino ($70), software (~$100), and a collection of tools and supplies (~$150) to provide a platform for laboratory and design projects. Major portions of the Living with the Lab experience have been implemented at four universities across the country.

The Living with the Lab approach includes all four of the pedagogical strategies listed (active learning, project-based learning, self-directed learning, and learning technologies). However, it is the relatively recent availability of inexpensive measurement/control hardware and software that has made student-ownership of a sophisticated laboratory platform practical for large groups. Our primary objective is to foster a can-do, entrepreneurial spirit through a constant back and forth between fundamentals and applications. Fundamental topics include circuits, linear regression, conservation of energy, material balance, statics, and mechanics of materials. First-year applications include building and testing a centrifugal pump, assembling and programming a mobile robot, building a system to control the temperature and salinity of water, implementing sensors for engineering applications, and designing and prototyping a smart product. The Living with the Lab experience provides opportunities to introduce transportation-related projects to first-year engineering students. There are a variety of transportation-related sensor projects that were implemented in ENGR 122, including

- *Traffic Counter*. Students implemented a motion sensor to detect passing pedestrians, bicyclists or vehicles, as shown in Figure 1. The PIR motion sensor detects changes in infrared light from 0 to 30 feet and produces a HIGH voltage when an object is detected. First-year students wrote a simple counting program to do elementary traffic studies.
- *"Radar" Gun*. An ultrasonic distance sensor works by sending an ultrasonic chirp out of a speaker and listening for the reflected sound wave using a microphone. The experimental setup is depicted in Figure 2. Distance is computed by measuring the time-of-flight of the sound wave. A program can be written to compute the speed by measuring two successive distances and dividing by the time between these measurements. Students wrote their own programs then monitored traffic speeds and tabulated the results as a function of vehicle type, driver demographics, and time of day.
- *Transportation Noise Measurement*. This project allows beginning students to measure and tabulate traffic noise, providing them a glimpse into aspect of modern highway design (see Figure 3). Students implemented a simple microphone board and saw how the analog voltage varies for different types of vehicles on different road surfaces. Students then tabulated these results and suggested ways to reduce noise levels through pavement design and barrier placement.
- *Environmental Quality and Transportation*. This project allows students to measure water quality parameters from water runoff from different surfaces paved with different materials, such as asphalt, concrete, parking-lot sealcoat, brick, and non-paved surfaces, using traditional sensing devices that are readily available for in-situ measurements.

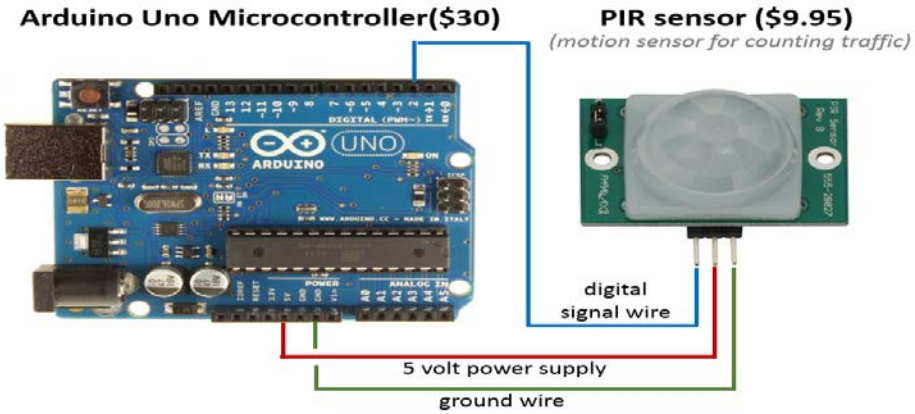

Figure 1 – Hardware configuration for a traffic counter.

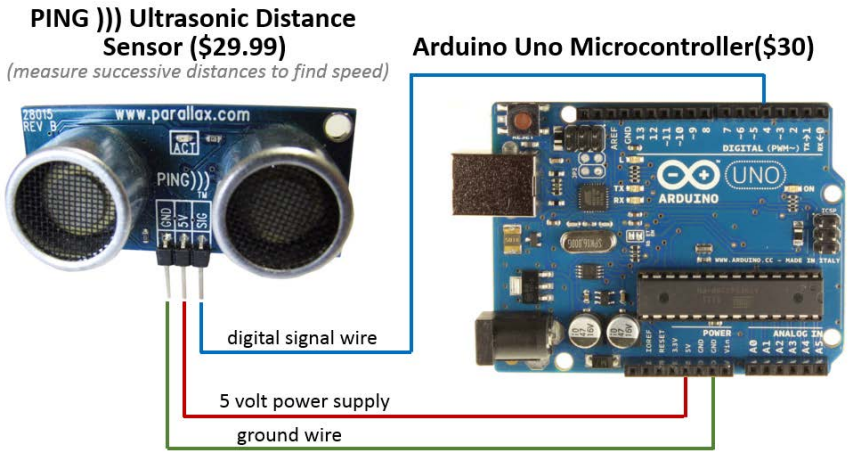

Figure 2 – Hardware configuration for a radar gun.

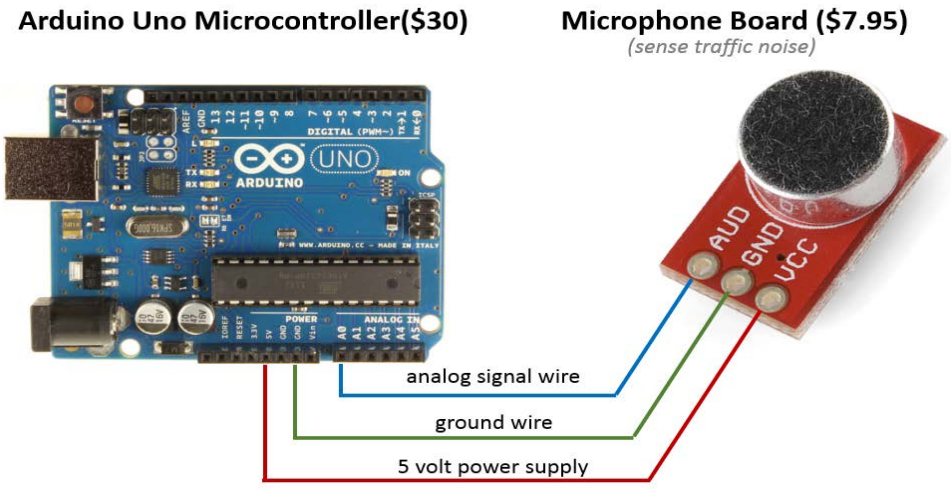

Figure 3 – Hardware configuration for roadway noise measurements.

Since all engineering students, including Civil Engineering majors, become competent in sensing and measurement applications, the first-year experience provides the student-owned hardware and technical competence needed for students to implement meaningful transportation projects when they begin taking upper level engineering courses. These courses range from transportation/traffic engineering to structure engineering, engineering physics, geotechnical engineering. Examples projects are listed below.

- *Acceleration and Tilt*. Students can create an instrument to measure and log the inclination of a road surface using an accelerometer, as shown in Figure 4. There, an ADXL335 3-axis accelerometer is used to measure accelerations in the x, y and z directions. Computing angle is performed using simple trigonometry as illustrated. The accelerations inside a vehicle can also be measured to estimate the radius of a curve, knowing the speed and normal acceleration.

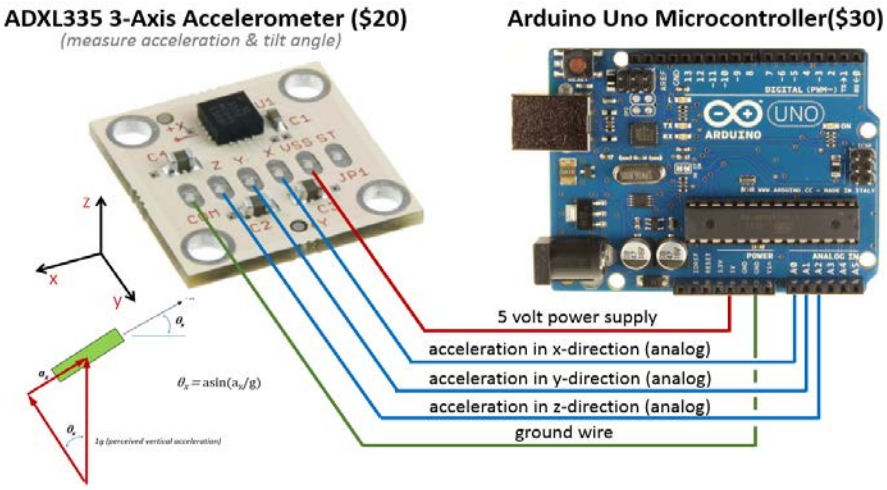

Figure 4 – Hardware configuration for tilt and acceleration measurements.

- *Strain Monitoring of Structures and Data Logging*. Engineering students enrolled in a sophomore-level circuits course can use the hardware from the freshman year to measure and log strains (see Figure 5). This project makes use of an instrument amplifier, a strain gage, a SD card, a Wheatstone bridge circuit and an Arduino. This inexpensive data logging system can be utilized for other activities where long-term data histories are need (such as logging the temperature of a bridge deck, the air and nearby soil to understand bridge icing).

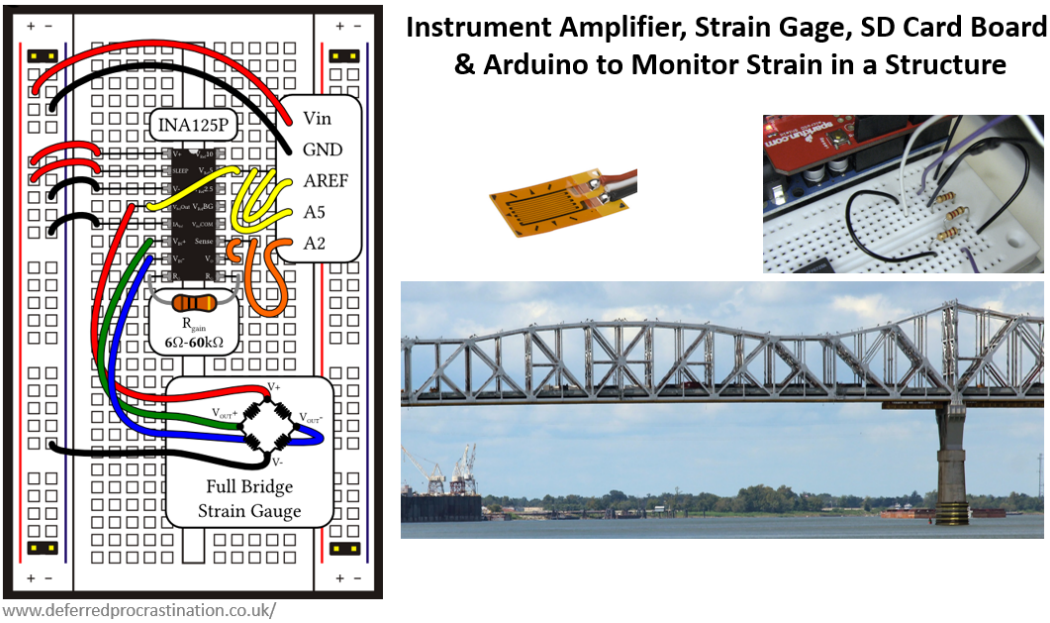

Figure 5 – Hardware configuration for data logging and strain measurement.

- *Stopping Distance Measurement*. Students will learn about and take measurements of stopping distances. The ultrasonic distance sensor presented earlier in Figure 2 can be used for this project. Students would get to see how braking distances are affected by properties of a paved surface and contact surface and presence of water in a lab environment.
- *Self-Driving Vehicles*. The ultrasonic distance sensor presented earlier in Figure 2 can be mounted on a line of robots (which all students have from their freshman year) to understand parameters which are important for self-driving cars, such as separation distance and relative speed. Figure 6 shows an instructor preparing to initiate the autonomous "following behavior" of a string of robots.

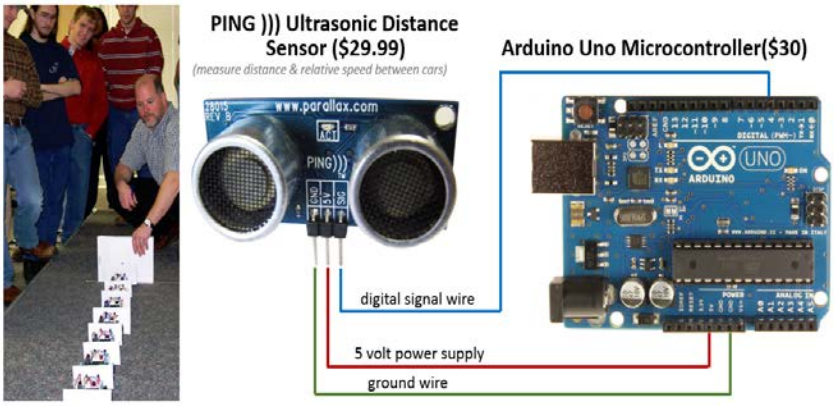

Figure 6 – Hardware for self-driving robots, with an instructor preparing to launch a self-driving event.

In addition to implementing these projects at various levels in the college classrooms, outreach educational efforts included various activities listed below.

- High school teachers involved in hand on STEM courses from northern Louisiana were invited to the Tech campus for a training workshop. They were trained and given a variety of the sensor previously described as a part of the training kit for them to implement specifically chosen multi-disciplinary projects at their respective high schools.
- The multi-disciplinary projects for high school teachers and students from this grant included data collection and analysis for measuring velocity vectors from moving vehicles; rainwater runoff and role of various surfaces in flashfloods; measurement of average speed of traffic; measurement of static and kinetic friction; demonstration, data collection and analysis for kinetic and static energy relationship; measurement and analysis of traffic noise data; challenge activity for designing safer transportation barriers. In addition, participants were asked to team up and adopt an activity that was a part of the training workshop and make necessary changes for it to be even better suited to their classes. In the end participants made presentations and evaluated designed hands-on activities. These activities long with previously described projects that were developed for college-level students were uploaded on project website for other schools and universities to implement as suited to their curricula. Investigators presented results, lessons learned, and impacts of this project at a couple of conferences. One such presentation was at Seventh Annual First Year Engineering Experience Conference (FYEE) - Enhancing the First Year of Engineering Education hosted by Virginia Polytechnic Institute and State University in Roanoke, VA during August 2-4, 2015. The conference is partially supported by American Society for Engineering Education (ASEE) First Year Programs Division. The project team (Marisa Orr, Sanjay Tewari, David Hall and Norman Pumphrey) collaborated on a presentation titled “Does a Technology-Rich Transportation Engineering Experience Increase Interest in Civil Engineering?” Other presentation based on this project was presented at the Second Mid Years Engineering Experience Conference Slump to Jump! Hosted at Texas A&M University, College Station, TX during March 30 - April 1, 2016. The PI (Sanjay Tewari) and one of the Co-PIs (Marisa Orr) collaborated with Louisiana Tech transportation engineering faculty Nazimuddin Wasiuddin on implementation of traffic camera in upper level transportation/traffic engineering course. The title of the presentation was “Traffic study using a video camera and an image processing software: Lessons learned”.
- Multiple student organizations that are on campus at Tech, such as the Society of Women Engineers (SWE) and American Society of Civil Engineers (ASCE) were invited to be a part of the project outreach efforts high school students.

Students participating in various summer camps at PVAMU were targeted. PVAMU regularly hosts STEM and Engineering summer camps for students from underrepresented minorities. The Exxon-Mobil Bernard Harris Summer Science Camp, Minority Introduction to Engineering and Science (MITES) organized by the Pre College Enrichment Institute (PCI) at PVAMU, College of Engineering Enhancement Institute (CE2I) and Research Experience for High School (REH) Students are specific camps that were part of project specific outreach and technology transfer activities. These camps were attended by students from junior high through high school.

- Additional outreach activities for junior high and high school students were organized via special event that are held regularly at the Tech campus such as Engineering & Science Day. Tech has been successfully hosting such events for many years, so the infrastructure was in place to accommodate SPTC projects in a very cost effective manner. We were able to reach out to well over 1000 students each year of the project duration to bring their focus to the technology-rich side of transportation engineering, and to motivate them to pursue careers in this exciting field.

Specific tasks numbered from one to seventeen are mentioned in following section along with expected timeline of the project.

1.6.2. Chronology of the Project

Tasks were spread over two separate years as shown in Table 1 and 2. The project was supposed to start initially in June of 2014 and the proposed end was in May of 2016. However, there were some delays in setting up the account. The actual start of the project happened in August of 2014 and it ended in September of 2016 (with 2 months of no-cost extension). Various outreach activities were run throughout both years and were coordinated with on-going educational and outreach activities that were already planned at Louisiana Tech University. The timeline that was originally proposed for both years (year 1 and year 2) are presented in Table 1 and Table 2 respectively. Since the actual start date was delayed, many activities that were planned for the summer of 2014, had to be scheduled for next summer (summer of 2015) and same was done for activities that were originally planned for summer of 2015 (re-scheduled to summer of 2016). The actual/modified timelines that were followed in the project for both years are provided in Table 3 and Table 4.

Table 1 – Proposed First Year Timeline 2014-2015

Task Name	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Task 1 - Final selection of projects to be implemented	x	x										
Task 2 - Seek out participating high schools and universities in SPTC region	x	x	x									
Task 3 - Technical preparation (hardware + instructions + reviews)	x	x	x	x								
Task 4 – Training Workshop for Louisiana Tech faculty		x	x									
Task 5 – Training workshop for high school teachers		x	x									
Task 6 – Various outreach activities		x	x	x	x	x	x	x	x	x	x	x
Task 7 – Implementation and inclusion of technology-rich transportation projects at freshmen engineering level at Louisiana Tech				x	x	x	x	x	x	x	x	x
Task 8 – Annual report											x	x

Table 2 – Proposed Second Year Timeline 2015-2016

Task Name	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Task 9 – Review and revise projects	x	x										
Task 10 – Invitations to various universities in SPTC region for faculty training	x	x										
Task 11 – SPTC region university faculty training workshop		x	x									
Task 12 – Feedback and follow up with high school teachers who received training and implemented projects in their classes				x	x	x						
Task 13 – Publication and sharing projects and related information online						x	x					
Task 14 – Same as task 6 - Various outreach activities		x	x	x	x	x	x	x	x	x	x	x
Task 15 – Implementation and inclusion of technology-rich transportation projects at freshmen engineering level at Louisiana Tech				x	x	x	x	x	x	x	x	x
Task 16 – Implementation at upper level transportation engineering classes at Louisiana Tech								x	x	x	x	x
Task 17 – Final report											x	x

Table 3 – Actual First Year Timeline 2014-2015

Task Name	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Task 1 – Final selection of projects to be implemented	x	x										
Task 2 – Seek out participating high schools and universities in SPTC region		x	x	x	x	x	x	x	x			
Task 3 – Technical preparation (hardware+ instructions +reviews)			x	x	x	x	x	x				
Task 4 – Training workshop for high school teachers and related activities									x	x		
Task 5 – Training Workshop for Louisiana Tech faculty and related activities											x	x
Task 6 – Various outreach activities				x	x	x	x	x	x	x	x	
Task 7 – Implementation and inclusion of technology-rich transportation projects at freshmen engineering level at Louisiana Tech	x	x	x	x	x	x	x	x	x	x	x	x
Task 8 – Implementation at upper level transportation engineering classes at Louisiana Tech		x	x	x	x							
Task 9 – Annual report												x

Table 4 – Actual Second Year Timeline 2015-2016

Task Name	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Task 9 – Review and revise projects	x	x	x									
Task 10 – Invitations to various universities in SPTC region for faculty training						x	x	x				
Task 11 – SPTC region university faculty training workshop									x	x		
Task 12 – Feedback and follow up with high school teachers who received training and implemented projects in their classes			x	x	x							
Task 13 – Publication and sharing projects and related information online					x	x	x	x	x	x	x	x
Task 14 – Same as task 6 - Various outreach activities		x	x	x	x	x	x	x	x	x	x	x
Task 15 – Implementation and inclusion of technology-rich transportation projects at freshmen engineering level at Louisiana Tech	x	x	x	x	x	x	x	x	x			
Task 16 – Implementation at upper level transportation engineering classes at Louisiana Tech	x	x	x	x	x	x	x	x	x			
Task 17 – Final report											x	x

2. Project Specific Activities

2.1. Summary of education and outreach STEM project activities at PVAMU

2.1.1. Exxon-Mobil Bernard Harris Summer Science Camp at Prairie View A&M University (2015)

The Exxon-Mobil Bernard Harris Summer Science Camp (EMBHSSC) was hosted during June 14-26, 2015 at Prairie View A&M University (PVAMU) to provide activities, experiments, projects, and field experiences for students entering 6th, 7th, or 8th grade in the Fall of 2015. The camp promotes science, technology, engineering, mathematics education and supports historically under served and underrepresented students with limited opportunities. Grade 5, 6, or 7 students who have an interest in science and mathematics and at least a B average in science and mathematics were eligible. The recruitment area of this camp covered 11 different counties in Texas (Austin, Burleson, Brazos, Colorado, Fayette, Lee, Grimes, Montgomery, Waller, Washington and Wharton). Figure 7 shows SPTC project activities during a summer camp at PVAMU organized by the PI.

Figure 7 – SPTC project activities during a summer camp at PVAMU.

The PI with the help of Co-PI (Dr. Kommalapati) was able to connect with EMBHSSC. Dr. Tewari traveled to PVAMU on May 24. Next day, the PI interacted with about 60 students (about 25 of them being female students) who were part of this camp and presented a PowerPoint presentation focused on transportation engineering and its various aspects including future of transportation and various careers related exciting opportunities. This interactive and educational presentation laid foundation for students to participate in a small scale simulation focused on transportation and traffic

engineering fundamentals. They raced remote controlled cars on a race track that had various obstacles including steep slope, sharp turns, bumps, speed limitations and public safety. Afterwards students shared their experiences and participated in an interactive discussion on role of science and engineering in overcoming these challenges. It helped them understand various transportation concepts at a deeper level and exposed them to many educational and career related opportunities. In addition to Engineering other aspects having a close nexus with transportation such as Energy, Environment, Design and Safety were also covered. Pictures of this event are attached at the end of the report.

2.1.2. Pre College Enrichment Institute (PCI) Workshop – Minority Introduction to Engineering and Science (MITES) (2015)

The PVAMU has sponsored the Institute for Pre-College Enrichment (PCI), a two-week residential summer program, for talented high school students for many years. The mission for PCI is to help prepare students for the new school year and assist them in making early plans to pursue a college education in an area that interest them most. MITES is offered to highly competitive students interested in engineering, engineering technology, computer science, physics, chemistry and mathematics. MITES is co-sponsored by the Roy G. Perry College of Engineering at PVAMU. This year, the PI with the help of Co-PI (Raghava Kommalapati) was able to connect with PCI-MITES. Figure 8 shows students learning about transportation engineering, future of transportation and career options.

Figure 8 – MITES 2015 student learning science behind highway design and safety issues as a part of SPTC project.

On May 25, the PI interacted with students (about 25) who were part of this workshop and presented a PowerPoint presentation focused on transportation engineering and its

various aspects including future of transportation and various careers related exciting opportunities. This interactive and educational presentation laid foundation for students to participate in a small scale simulation focused on transportation and traffic engineering fundamentals. They raced remote controlled cars on a race track that had various obstacles including steep slope, sharp turns, bumps, speed limitations and public safety. Afterwards students shared their experiences and participated in an interactive discussion on role of science and engineering in overcoming these challenges. It helped them understand various transportation concepts at a deeper level and exposed them to many educational and career related opportunities. In addition to Engineering other aspects having a close nexus with transportation such as Energy, Environment, Design and Safety were also covered.

2.1.3. The Roy G. Perry College of Engineering Enhancement Institute (2016)

The Roy G. Perry College of Engineering Enhancement Institute (CE2I) at Prairie View A&M University is an innovative and intensive summer bridge-to-college program designed to prepare students for the rigors of an Engineering, Computer Science, or Technology Curriculum and to aid with the transition between high school and college. The Institute is a five-week residential program, where participants complete coursework in Math, Science, Technology, and Professional Development Activities. Students experience professional development activities including field trips to area engineering and technology industries; personal and professional development seminars and workshops.

Dr. Sanjay Tewari, met with 70 CE2I participants and organized a hands-on activity that involved a wide spectrum of science, technology, engineering and mathematics specifically focused to vehicles. Dr. Tewari first interacted with the group of students and presented them with a brief introduction of energy, speed, velocity and velocity vectors. He then went on to ask students importance of taking field measurements in any scientific and engineering study. Through this interaction, Dr. Tewari was able to point out that if a measurement/experiment is not planned properly, the collected data may not be of good use. When probed by Dr. Tewari, students contributed by pointing out multiple possible sources of errors that they needed to be aware of in addition to proper data collecting procedure.

Students were shown how the data that were going to collect will be used for various math and science fundamentals that they learned. Students learned that engine speed, moving metal parts, vehicle moving against air friction, contact of tires with pavement and sound of exhaust gases coming out of tail pipe are some of the sources for the noise energy coming from vehicles. Dr. Tewari also talked about momentum and increased amount of fuel being burned for higher speeds. Fuel and energy consumption

as well as noise level could be reduced if vehicles are driven at a constant speed rather than frequent braking and acceleration.

The hands-on activity was focused on sound and speed of moving vehicles. Students used to noise meters to measure noise levels of vehicles at various speeds along and the perpendicular of the roadway. Students were divided in a group of seven students per group. Four groups took measurements along the roadway and six groups were positioned at increasing perpendicular distance from the street. Similar arrangement was used for speed measurements of vehicles being driven at various known speeds. Multiple radar speed guns were used for these measurements. Vehicles were driven by volunteer student workers at instructed constant speeds.

Once the field measurement was over, the collected data was used to create various graphs that demonstrated how noise energy fades away as you move away from the source. Also, students used actual speed of the vehicles and trigonometry to relate to the various display speeds they recorded at various positions (velocity components). Some of the data was good and it helped students to understand experiment design, data collection, math and science behind it and how it was used to plot various graphs. Some of the data was not good and the students tried to explore possible reasons for not getting a good data. Over all, it was a good hands-on activity that students really like. Below (Figure 9) are some of the sound meters and radar guns that were used in this activity. Also, Figure 10 shows the configuration of student groups that was used for data collection.

Figure 9 – (a) Display view of the speed radar gun. (b) Making speed radar gun ready for the use. (c) Sound meter used in the activity.

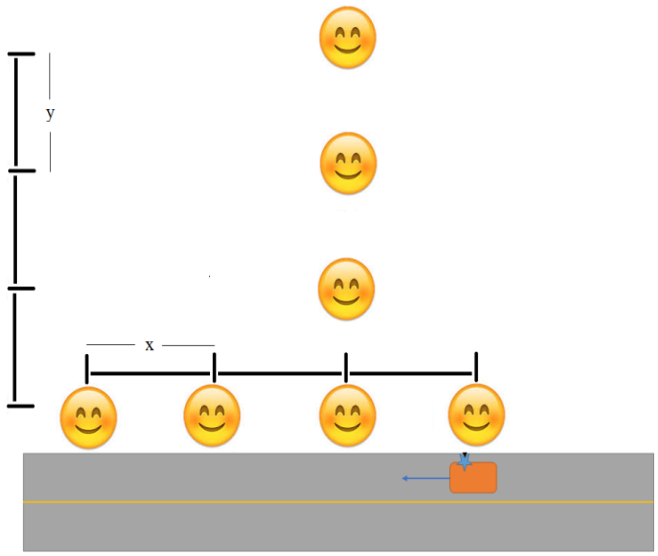

Figure 10 – Configuration used for different groups for field measurements.

2.1.4. Research Experience for High School (REH) Students (2016)

The REH Program is a part of Summer Research Experience Program at PVAMU. It is a non-residential 6-week program open to talented area high school students. Participants are matched with a faculty mentor on a research project related to the student's career interests. Additionally, the program features group activities, including a weekly meeting in which principles of scientific investigation and ethical aspects of human and animal experimentation are discussed. Participants have the opportunity to attend scientific seminars and workshops. Participants are involved in program activities approximately 35 hours each week. Selected participants develop professional skills, interact with like-minded peers and college students, and provided with helpful college related information. Participants also receive a certificate of completion in addition to other possible merit awards during the closing ceremony. Dr. Tewari met with 2016 REH students on July 29, 2016. There were 16 students in this group. The group of students was comprised of underrepresented communities. There were more female students than male students. Dr. Tewari made a presentation on current state of transportation engineering and various pathways that are there for a degree and a career in the broad field of transportation engineering. Students showed high level of interest in various career opportunities in this field. In addition, Dr. Tewari also talked about the smart vehicles and smart transportation systems that are currently undergoing multiple levels of field testing and the future of transportation in United States.

2.2. Summary of education and outreach STEM project activities at LTU

2.2.1. Engineering and Science Day (2015)

Engineering and Science Association of Louisiana Tech University recently hosted this major College of Engineering and Science (COES) event focused on high school students. This year this event was hosted on April 15 and about 500 students from over 70 different high schools attended it.

A group of COES faculty, involved with Southern Plains Transportation Center (SPTC), participated in this event. This group (Dr. David Hall, Dr. Marisa Orr, Dr. Norman Pumphrey, and Dr. Sanjay Tewari) set up a Transportation Engineering booth for students to come in and participate in hands on fun and educational activities. The group is working on a project titled Technology-Rich Transportation Engineering Projects funded by SPTC and Louisiana Tech University.

Students visited the booth in groups of 25 to 35 students at a time. They were presented a PowerPoint presentation focused on transportation engineering and its various aspects including future of transportation and various careers related exciting opportunities. This interactive and educational presentation laid foundation for students to participate in a small scale simulation focused on transportation and traffic engineering fundamentals.

Students, in teams of 4-8, were invited to participate and compete over a racing track using remote controlled cars. The race track was designed to bring their attention to various issues such as safety, super elevation, friction, momentum, speeding and transportation issues. Students really enjoyed competing and learning about transportation issues. One team from each group of students was declared winner for completing the task in the least amount of time. Each member of winning team received a goodies bag with some snacks. Figure 11 shows the project team members getting ready for 2015 Engineering and Science Day at Louisiana Tech University (left) and Dr. Pumphrey introducing high school students to transportation engineering (right). Figure 12 (left) shows a group of high school students and their parents listening to a presentation by Dr. Pumphrey on transportation engineering and future career options before participating in to specifically designed transportation/traffic activity that covered traffic safety, super elevation, friction between surfaces and relationship between speed and vehicle control. SPTC Transportation Engineering booth (top right). Participants going over hands-on activity focused on traffic and pavements (bottom right).

Figure 11 – The team members getting ready for 2015 Engineering and Science Day at Louisiana Tech University (left). Dr. Pumphrey introducing high school students to transportation engineering (right).

Figure 12 – Dr. Pumphrey discussing various modes of transportations with high school students (left). SPTC Transportation Engineering booth (top right). Participants going over hands-on activity focused on traffic and pavements (bottom right).

2.2.2. Engineering and Science Day (2016)

Engineering and Science Association of Louisiana Tech University recently hosted this major College of Engineering and Science (COES) event focused on high school students. This year Engineering and Science (E&S) Day event was hosted on April 11 and about 1000 students and parents from over 75 different high schools attended it.

Dr. Sanjay Tewari one of COES faculty and the PI of a project sponsored by Southern Plains Transportation Center (SPTC), participated in this event. Dr. Tewari set up a Transportation Engineering booth for students to come in and participate in hands on fun and educational activities. The group is working on a project titled Technology-Rich Transportation Engineering Projects funded by SPTC and Louisiana Tech University.

Students visited the booth in groups of 25 to 35 students at a time. They were presented a PowerPoint presentation focused on transportation engineering and its various aspects including future of transportation and various careers related exciting opportunities. This interactive and educational presentation laid foundation for students to participate in a small scale simulation focused on transportation and traffic engineering fundamentals.

Students, in teams of 4-8, were invited to participate and compete over a racing track using remote controlled cars. The race track was designed to bring their attention to various issues such as safety, super elevation, friction, momentum, speeding and transportation issues. Students really enjoyed competing and learning about transportation issues. One team from each group of students was declared winner for completing the task in the least amount of time.

2.2.3. First Year Engineering Experience at Tech

Multiple transportation engineering projects, as previously described under Methodology and Tasks section, were implemented in an honors section of ENGR 122: Engineering Problem Solving III during the spring quarter of 2015. ENGR 122 is a first-year engineering course that is taken by all engineering students at Louisiana Tech University. Students used an ultrasonic distance sensor along with an Arduino microcontroller to build a speed sensor. After hearing an introduction to the field of transportation engineering, students took their speed sensors to a nearby roadway to measure traffic speed and compare this speed to the posted limit. A follow-up survey was used to determine the impact of the transportation project on the attitudes of first-year students to transportation engineering. While the results are not dramatic and certainly not statistically significant, it is promising that the section that did the activity shows the highest interest in civil engineering. Ideally, students would be exposed to transportation engineering on multiple occasions, facilitating the development of their

interest over time. Future work will increase the sample size and refine the activity. Similar project were also included in ENGR122 in the Spring of 2016. Figures 13 through 16 show students taking ENGR 122 (Engineering Problem Solving III) and learning about traffic engineering from Dr. Norm Pumphrey and Dr. David Hall before completing a project that made use of PING))) ultrasonic distance sensors (as shown previously in Figure 2) to make a device to record traffic speed.

Figure 13 – Speedometers collected from class (speeds collected in a subsequent class).

Figure 14 – Students collecting speeds using their PING))) based detectors and laptop computers.

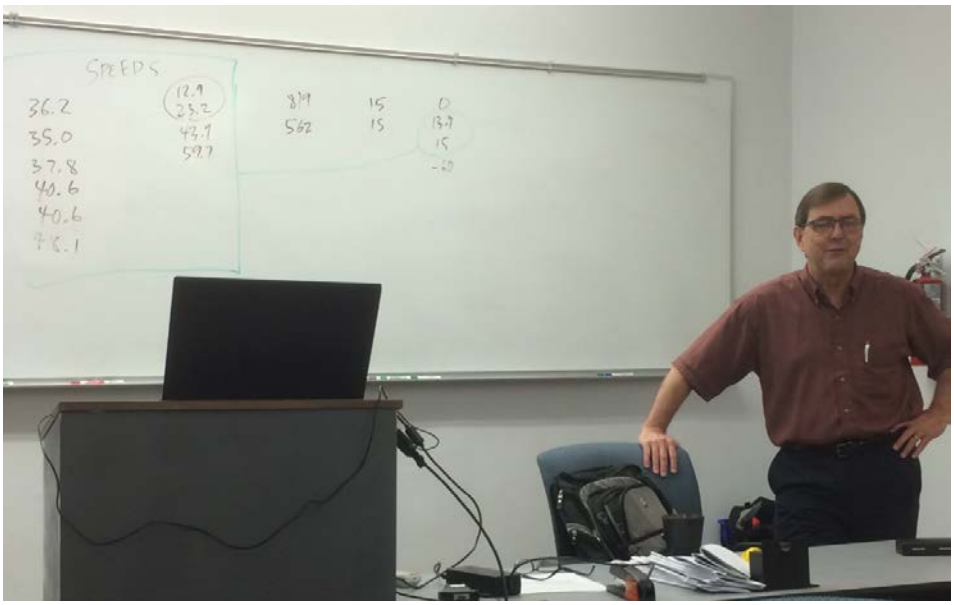

Figure 15 – Dr. Norm Pumphrey explaining the career opportunities of traffic engineering to students.

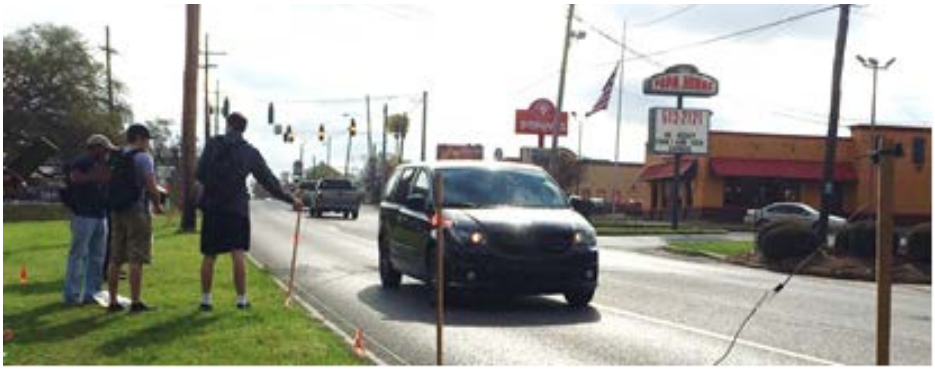

Figure 16 – Students collecting speeds using their PING))) based detectors and laptop computers.

2.2.4. Upper Level Transportation Engineering Experience at Tech

2.2.4.1. CVEN332 (Highway Engineering)

Students used hand held radar guns that resemble cell phones and were able to conduct speed study for various locations in the city of Ruston. They recorded 100-150 readings for each location and were able to do basic speed study analysis and speed distribution. Students enjoyed playing with these little but effective tools while actually doing fundamental traffic study. This hands-on project made learning easy and generated deeper level of interest towards traffic engineering among students.

2.2.4.2. CVEN425 (Traffic Engineering)

Students got to use a traffic camera as shown in the Figure 17 that was purchased from funds of this project. Students were able to see differences in counting vehicles in a traditional way versus recording the traffic and getting video analyzed by a traffic counting software. In addition to this, set of traffic lights and controllers were purchased as part of this project to enhance students' overall educational experience and provide them more hands-on activities. The installed lights as shown in Figure 18 are being used in transportation and traffic engineering classes.

Figure 17 – Traffic camera (with all its components) purchased and being used in transportation and traffic engineering classes at Louisiana Tech University.

Figure 18 – Traffic lights and the controllers purchased and being used to help students with more hands-on experience in traffic and transportation engineering courses at Louisiana Tech University.

2.3. Training Workshops at LTU for Educators

There were three three-day workshops that were hosted at LTU campus. These workshops targeted educators at local level (north Louisiana) as well as at national

level. The participating educators varied from high school STEM courses to university faculty involved at freshman and upper level civil/transportation engineering courses. The specific names and the dates of these workshops are provided in Table 5 below.

Table 5 – Training workshops for Educators hosted at LTU Campus

S.N.	Name	Date
1.	Three-Day High School Teacher Workshop at Louisiana Tech	July 8-10, 2015
2.	Three-day Training for Louisiana Tech University Faculty	August 17-19, 2015
3.	Three-Day University Faculty Training for Participating Universities from SPTC Region and Beyond	July 24-26, 2016

The announcement of these workshops were made ahead of time and information handouts were sent out to target participants via emails directly and in some cases indirectly through school boards, civil engineering department heads and/or chairs, and American Association of Engineering Association (Civil Engineering Division). The applications and emails were screened carefully for suitability of applicants' educational background along with their involvement in the area of education as profession. The following section provides more information on each of these workshops.

2.3.1. Three-Day High School Teacher Workshop at Louisiana Tech

This was the first in a series of three workshops that were hosted at Louisiana Tech University. The focus of this workshop was to reach out to high school educators active in teaching STEM courses. High school students who are not adequately informed and exposed to technology-rich side of civil and transportation engineering were ultimate target of this workshop. The workshop was designed to train high school teachers in transportation/civil engineering specific hands-on projects that these teachers could use in their classes and explain based on science and mathematics courses that are being taught in their high schools.

School boards and supervisors in North Louisiana were contacted via email and were provided with information on this SPTC sponsored work that was to be hosted at Louisiana Tech campus. Interested teachers were asked to provide information on classes they have taught (or are actively involved in teaching). The project team carefully reviewed all applicants and invited a group of 12 high school teachers from five different high schools from multiple cities located in North Louisiana. In addition to these teachers, the project team also invited three members of the UTeachTech program at Louisiana Tech University. The mission of UTeachTech is to increase the number of STEM educators in K-12 schools and to improve STEM educator preparation. In 2014, Louisiana Tech University, received a $1.45 million grant from the National Math and

Science Initiative and the Howard Hughes Medical Institute in cooperation with the UTeach Institute to implement the UTeach program. The participants from UTeachTech were Diane Madden (STEM Education Specialist and UTeachTech Assistant Director), Chris Campbell (UTeachTech Master Teacher) and Glenn Larson (UTeachTech Master Teacher). Table 6 provides the names of the participants, their affiliated schools/organizations and the names of the cities they were from. Multiple teachers from same schools were chosen to promote cross-collaboration in STEM classes and availability of multiple kits for an effective implementation of these projects.

Table 6 – Participants of Three-Day High School Teacher Workshop at Louisiana Tech and their schools/organizations

S.N.	Name	School/Organization	City and State
1.	Alicia Nevala	Union Parish High School	Farmerville, LA
2.	Amy Melton	Haughton High School	Haughton, LA
3.	Aundrea Weinreber	Haughton High School	Haughton, LA
4.	Chris Campbell	UTeachTech, LTU	Ruston, LA
5.	Debra Harlan	Haughton High School	Haughton, LA
6.	Diane Madden	UTeachTech, LTU	Ruston, LA
7.	Glenn Larson	UTeachTech, LTU	Ruston, LA
8.	Joshua O'Nishea	Haughton High School	Haughton, LA
9.	Lorna Skidmore	Airline High School	Bossier City, LA
10.	Martha "Ellen" Allen	Haughton High School	Haughton, LA
11.	Miki Wallingsford	Haughton High School	Haughton, LA
12.	Sam Morse	Airline High School	Bossier City, LA
13.	Stacey Brotherton	Haughton High School	Haughton, LA
14.	Theresa Cannon	Airline High School	Bossier City, LA
15.	Wanda Boothe	Mangham High School	Mangham, LA

Each participant was provided with resources and hands-on training during the workshop. The participants were compensated for their time and effort as proposed in the original proposal of the project. Each participant (except participants from UTeachTech program) received a stipend of $500. This amount included their fringe benefits. Also, each participant (except participants from UTeachTech program) was compensated with $400 for their travel and mileage for the three-day duration of the workshop. The project team made sure that participants were provided with a startup kit worth $500 for these teachers to implement these projects at their high schools. The specific topics and projects details covered in this workshop are listed in Table 7.

Table 7 – Project covered during Three-Day High School Teacher Workshop

S. N.	Project Details
1.	Measuring speed using a radar gun and using velocity vectors for speed measurements taken at an angle
2.	Rainwater quality, water runoff and effect of surface types on flash floods
3.	Traffic speed study
4.	Tire friction – static and kinetic friction
5.	Kinetic and potential energy of a vehicle
6.	Designing safe crash barriers
7.	Traffic noise measurement fundamentals

2.3.2. Three-day Training for Louisiana Tech University Faculty

This was the second in a series of three workshops that were hosted at Louisiana Tech University. The focus of this workshop was to training and resources to the faculty involved in freshman and upper level engineering courses. The training covered various aspects of Arduino based projects focused on wide field of civil and transportation engineering. The participating faculty was multidisciplinary in nature and was chosen to cover courses that are taught in freshman and sophomore years. The faculty specifically involved in ENGR 120 series made direct impact to all engineering freshman students going through a series of three courses (2 credit hours each in each quarter of the freshman year). Usually, students from majors other than civil engineering do not have a basic level of understanding of civil and transportation related technology based projects and activities. This workshop was planned and designed to provide the participating faculty enough background in Arduino based projects for them to be able to provide better explanations and examples in transportation and civil engineering related problems. This helps in recruiting students to transportation engineering not only from civil engineering but from all other majors if and when they decide to switch majors.

The training covered basics of Arduino programming, live demonstrations, and implementation of gained knowledge in transportation related design projects. In addition to this, participants gained insights in other STEM related activities that prepared them to provide transportation engineering related examples in mathematics and physics courses.

Each participant was provided with resources and hands-on training during the workshop. The participants were compensated for their time and effort as proposed in the original proposal of the project. Each participant received a stipend of $500. This amount included their fringe benefits. The participants were provided with a startup kit worth $200 for them to implement these projects in their classes. The project team and the participants engaged in scholarly discussion on various ways these project could be

modified and adopted at various levels for greater impacts. The feedback from participants was taken in to consideration for planning and implementation of the third proposed workshop for university faculty from SPTC region and beyond. The names and their main affiliation are shown in Table 8.

Table 8 – Participants of Three-Day Workshop for Louisiana Tech faculty

S.N.	Name	School/Organization
1.	Arden Moore, Ph.D.	Mechanical Engineering Nanosystems Engineering
2.	Arun Jaganathan, Ph.D.	Civil Engineering Construction Engineering Technology
3.	Daniel Scoggin, Ph.D.	Mechanical Engineering
4.	David Hall, Ph.D.	Mechanical Engineering
5.	David Meng, Ph.D.	Mathematics and Statistics
6.	John Easley, Ph.D.	Industrial Engineering
7.	John Shaw, Ph.D.	Physics
8.	Mahboubeh Madadi	Industrial Engineering
9.	Marisa Orr, Ph.D.	Mechanical Engineering
10.	Mary Moore, Ph.D.	Biomedical engineering
11.	Nazimuddin Wasiuddin, Ph.D.	Civil/transportation Engineering Construction Engineering Technology
12.	Norman Pumphrey, Ph.D.	Civil/transportation Engineering Construction Engineering Technology
13.	Sanjay Tewari, Ph.D.	Civil Engineering Construction Engineering Technology
14.	Stanley Cronk, Ph.D.	Industrial Engineering

2.3.3. Three-Day University Faculty Training for Participating Universities from SPTC Region and Beyond

For this workshop the project team reached out to university faculty involved mainly in transportation and traffic engineering field within SPTC region and beyond. Emails/application of interest were invited and potential participants were asked to provide information on their educational, research and professional background for the research team to determine appropriate match to the project requirements. Efforts were made to spread words about this workshop through SPTC, Civil Engineering division of ASEE and department heads and chairs of civil engineering at various university within the SPTC region.

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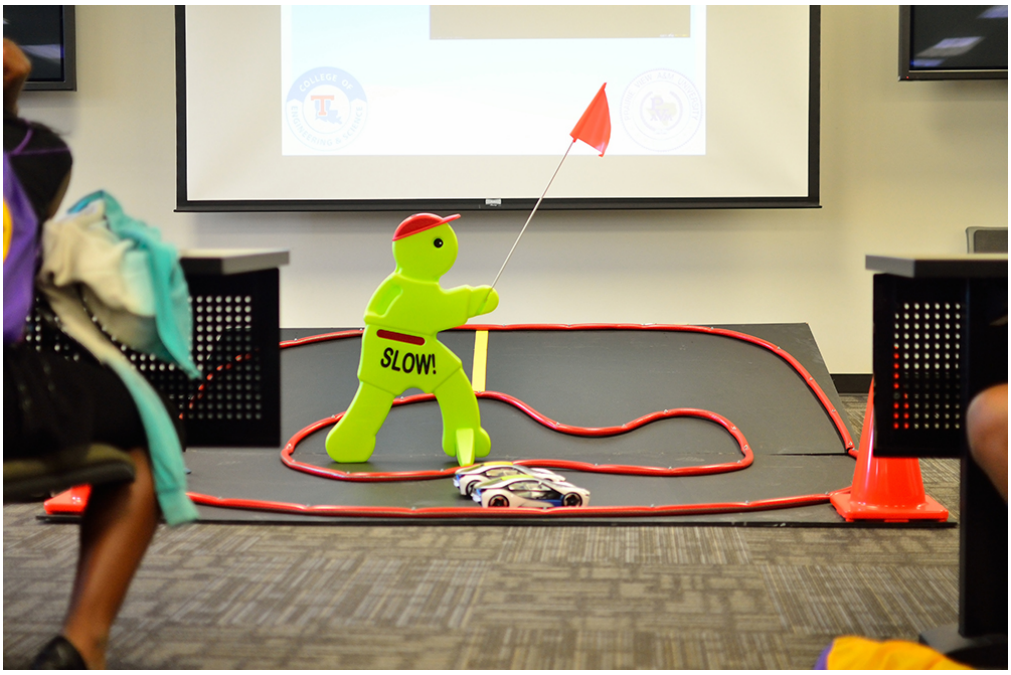
1. Hecker, D. E. Occupational employment projections to 2014, Monthly Labor Review, Office of Occupational Statistics and Employment Projections, Bereau of Labor and Statistics. November 2005
2. National Science Foundation, National Center for Science and Engineering Statistics. 2013. Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013. Special Report NSF 13-304. Arlington, VA. Available at http://www.nsf.gov/statistics/wmpd/
3. Carnevale, A. P.; Smith, N.; Melton, M. STEM Science Technology Engineering Mathematics, 2011, Center on Education and the Workforce, Georgetown University, Washington, DC. Available at https://georgetown.app.box.com/s/cyrrqbjyirjy64uw91f6
4. https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf

Appendices

Exxon-Mobil Bernard Harris Summer Science Camp at Prairie View A&M University

A1 – Dr. Sanjay Tewari interacting with Middle School students as part of Exxon Mobil Bernard Harris Summer Science Camp at PVAMU.

A2 – Dr. Tewari explaining how transportation simulation will take place.



A3 – The Transportation Engineering simulation setup.

PICTURES FROM 2015 E&S DAY

A4 – Dr. Pumphrey making a presentation on traffic and transportation to visiting high school students, teachers and parents.

A5 – The display before E&S activities.

PICTURES FROM 2016 E&S DAY

A6 – Students going through a video presentation as a part of SPTC activities on E&S Day.

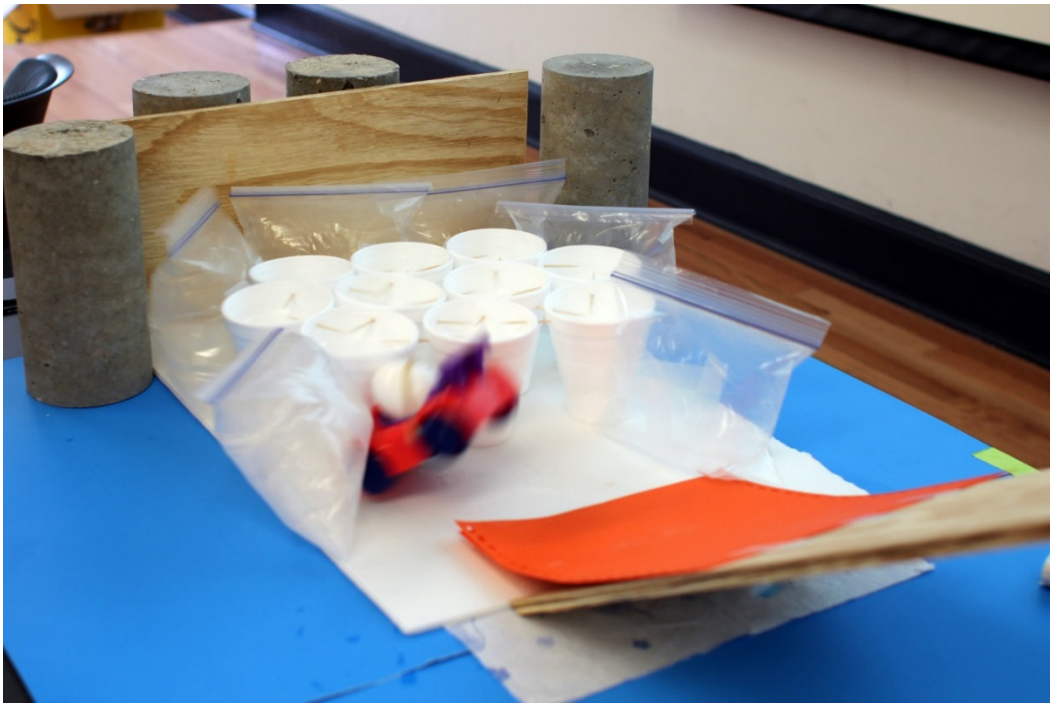
PICTURES FROM WORKSHOP FOR HIGH SCHOOL TEACHERS

A7 – Dr. Orr overseeing a hands-on activity of high school teachers.

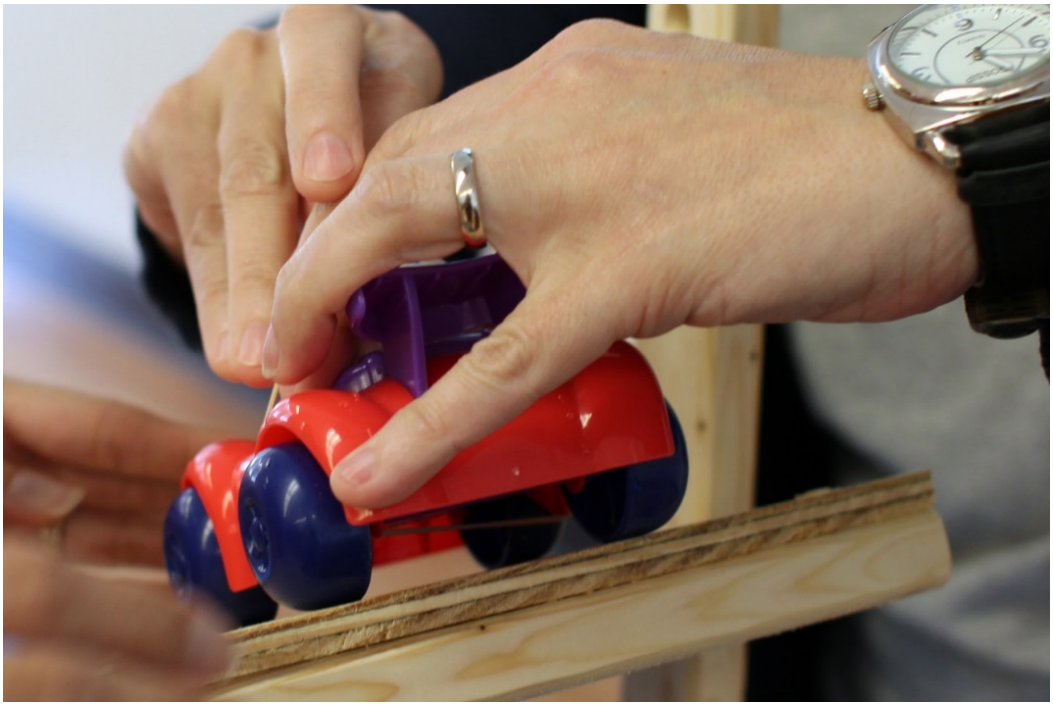
A8 – High school teachers collecting field data.

A9 – High school teachers collecting field data.

A10 – A group of high school teachers making a presentation.



A11 – Kinetic energy and egg carrying competition.



A12 – Kinetic energy and egg carrying competition.

A13 – Teachers testing their designs for kinetic energy and egg carrying competition.

A14 – Teachers with Dr. Tewari enjoying field demonstration of friction.

A15 – Teachers listening their peers about how these activities could be used for in their classrooms.

A16 – A group of teachers making a presentation to rest of the participants.

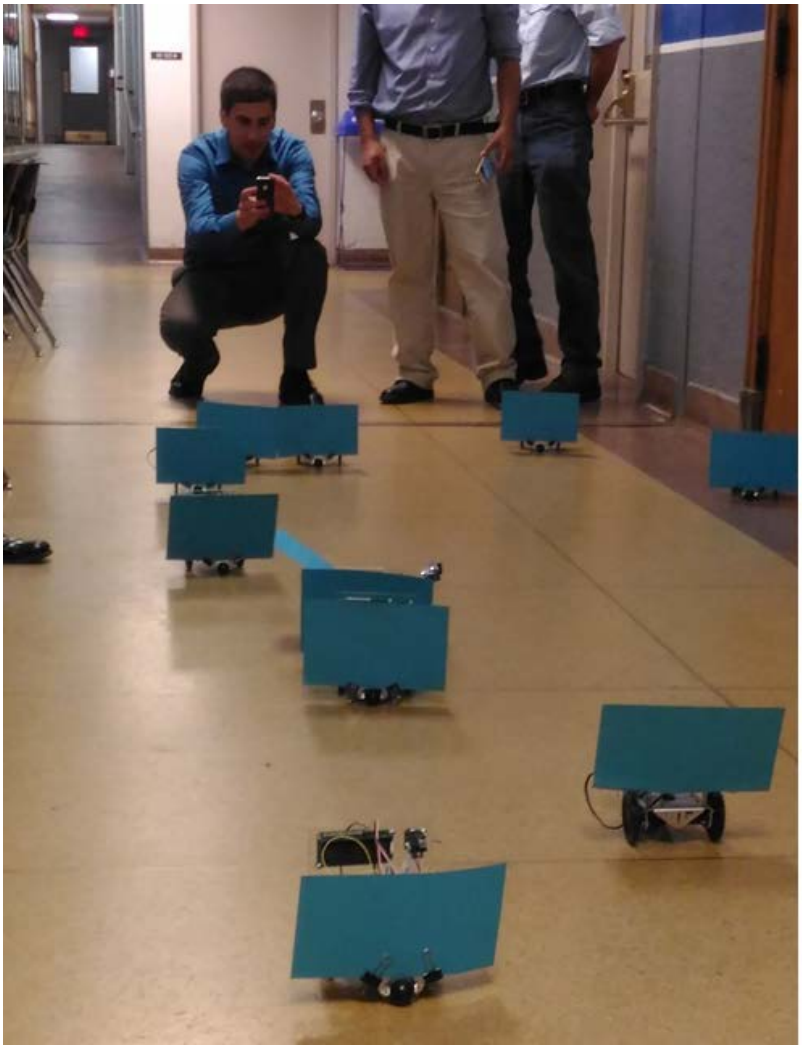
PICTURES FROM WORKSHOP FOR TRANSPORTATION FACULTY FROM SPTC REGION AND BEYOND

A17 – A group of professors collecting field data.

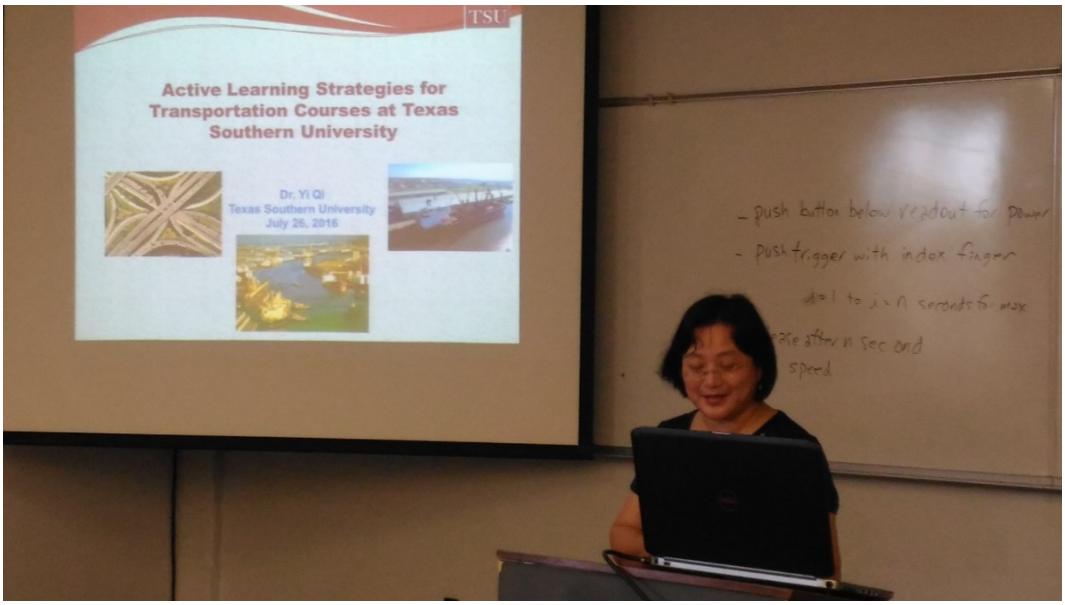
A18 – A group of professors collecting field data.

A19 – Mr. Palmer making a presentation on application of drones in transportation/traffic and other applied areas such as forestry.

A20 – Mr. Palmer making a live demonstration of capabilities of various drones.



A21 – Simulation of self-steering robots.



A22 – One of the presentations on symposium on active learning in transportation/traffic and civil engineering classes.

A23 – Another presentation on symposium on active learning in transportation/traffic and civil engineering classes.