



SOUTHERN PLAINS
TRANSPORTATION CENTER

**STEM Teacher Professional Development
and Student Outreach:
Transportation Engineering Series**

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SPTC14.1-01-F

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TECHNICAL REPORT DOCUMENTATION PAGE

1. REPORT NO. SPTC14.1-01-F	2. GOVERNMENT ACCESSION NO.	3. RECIPIENTS CATALOG NO.	
4. TITLE AND SUBTITLE STEM Teacher Professional Development and Student Outreach: Transportation Engineering Series		5. REPORT DATE October 12, 2018	
		6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) Cathy H. Allen, Sanjaya Senadheera, Priyantha Jayawickrama and Hongchao Liu		8. PERFORMING ORGANIZATION REPORT	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Texas Tech Center for Multidisciplinary Research in Transportation Texas Tech University Box 41023 Lubbock, Texas 79409		10. WORK UNIT NO.	
		11. CONTRACT OR GRANT NO. DTRT13-G-UTC36	
12. SPONSORING AGENCY NAME AND ADDRESS Southern Plains Transportation Center 201 Stephenson Pkwy, Suite 4200 The University of Oklahoma Norman, OK 73019		13. TYPE OF REPORT AND PERIOD COVERED Final August 2014 – October 2018	
		14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES University Transportation Center			
16. ABSTRACT <p>The nation is battling a critical global competitiveness void and falling further behind other countries with the severe lack of students pursuing, persisting and matriculating through higher education with degrees in STEM disciplines. Exacerbating the problem concerning transportation is an aging transportation workforce—the workforce is retiring in far greater numbers than it is being replenished by new graduates. The Southern Plains Transportation Center (SPTC) mission to prepare transportation professionals for leadership roles in professional and research careers in support of the nation’s transportation systems. SPTC Education Project 14.1-01 sought to address this problem from two sides: first, by reaching out to teachers of grades 6 through 12 through development workshops using transportation issues integrated into lesson planning in the STEM classes, and second, through engaging high school students to encourage interest in transportation careers. This project included three tasks:</p> <ol style="list-style-type: none"> 1. Teacher Development Workshops 2. Student Outreach and Educations Tours and Activities 3. Teacher Follow-Up <p>Over the course of the project, two two-day teacher development workshops were held, and one five-day high school student outreach event called Explore Engineering was conducted. Through the teacher development workshops, an estimated total of 1650 students was reached, and 11 high school juniors and seniors from Texas participated in Explore Engineering.</p>			
17. KEY WORDS Transportation, Engineering, Teacher Professional Development, Curriculum, Student Outreach		18. DISTRIBUTION STATEMENT No restrictions. This publication is available at www.sptc.org and from the NTIS.	
19. SECURITY CLASSIF. (OF THIS REPORT) Unclassified	20. SECURITY CLASSIF. (OF THIS PAGE) Unclassified	21. NO. OF PAGES 19	22. PRICE

METRIC CONVERSION

SI* (MODERN METRIC) CONVERSION FACTORS				
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)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
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)				
°C	Celsius	1.8C+32	Fahrenheit	°F
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

ACKNOWLEDGEMENTS

This project was funded by Southern Plain Transportation Center (SPTC). The project team would like to thank the support of the T-STEM Center affiliated with the Texas Tech Whitacre College of Engineering. We appreciate the commitment and hard work of several researchers and graduate students who made this research project a success. In particular, the efforts of Dr. Wesley Kumfer, Dr. Sang-Wook Bae, Dr. Hoyoung Seo, Tharanga Dissanayaka, Manil Hettiwatte and Dalton Menn must be mentioned.

STEM Teacher Professional Development and Student Outreach: Transportation Engineering Series

Final Report

October 12, 2018

by

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EXECUTIVE SUMMARY

The nation is battling a critical global competitiveness void and falling further behind other countries with the severe lack of students pursuing, persisting, and matriculating through higher education with degrees in STEM disciplines. Exacerbating the problem concerning transportation is an aging transportation workforce—the workforce is retiring in far greater numbers than it is being replenished by new graduates. The Southern Plains Transportation Center (SPTC) mission is to prepare transportation professionals for leadership roles in professional and research careers in support of the nation’s transportation systems. SPTC Education Project 14.1-01 sought to address this mission from two sides: first, by reaching out to teachers of grades 6 through 12 through development workshops using transportation issues integrated into lesson planning in the STEM classes, and second, through engaging high school students to encourage interest in transportation careers. This project included three tasks:

1. Teacher Development Workshops
2. Student Outreach and Education Tours and Activities
3. Teacher Follow-Up

Over the course of the project, two two-day teacher development workshops were held, and one five-day high school student outreach event called Explore Engineering was conducted. Through the teacher development workshops, an estimated total of 1650 students was reached, and 11 high school juniors and seniors from Texas participated in Explore Engineering.

INTRODUCTION

PROBLEM STATEMENT

The nation is battling a critical global competitiveness void and falling further behind other countries with the severe lack of students pursuing, persisting, and matriculating through higher education with degrees in STEM disciplines, or being prepared to enter the workforce from high school and effectively contribute to the economy in the STEM and related career fields. Correspondingly, the United States faces systemic educational crises that have been brewing for many years on a variety of fronts – from pre-kindergarten through high school and beyond (Nationwide STEM Network, March 2014), (Creusere, et al., January 2014), (T-STEM Initiative, March 2014). Specific to transportation workforce preparation, the STEM Transportation Series grades 6-12 educator professional development workshops and student outreach programs developed in this project provided inquiry-based curriculum to educate, create exposure, and increase the likelihood for recruiting students into college/university majors and career fields in the transportation industry.

BACKGROUND

In December 2005, Texas Governor Rick Perry signed Executive Order RP 53 creating the Texas STEM Network and seven T-STEM Centers, in coordination with Educate Texas (formerly the Texas High School Project) (T-STEM Initiative, March 2014). Since that time, the Texas STEM network has grown to 77 designated schools and continues to fulfill its mission by supporting non-designated schools statewide whether public, charter or private.

The STEM network provides a school reform model where schools and teachers focus on preparing students for real-world experiences through teaching/learning modules based on student inquiry, college and career readiness and 21st-century skills (T-STEM Academies, TEA, March 2014). Students in Early College High Schools (ECHS) and T-STEM designated academies outperform students in non-T-STEM academies in most assessment areas (Montecel, 2014; T-STEM Academies, TEA, March 2014). Goals of the STEM program include improving instruction and academic performance of students in STEM designated schools by increasing the number of students entering postsecondary studies and careers in science, technology, engineering, and mathematics; facilitating the promotion of quality school leadership that supports school redesign efforts, quality teacher recruitment, and improved teacher preparation; and assisting in long-term educational and economic development and alignment of these fields (Montecel, March 2014; T-STEM Academies, TEA, March 2014).

At the Texas Tech T-STEM Center, training is free or provided at a reduced cost to educators in designated schools. Teachers from non-STEM schools also have access to professional development, sometimes with a nominal cost. Workshops are hosted at various locations – center campus facilities, in collaboration with Regional Educational Service Centers, Science Spectrum, high schools in the area/region or other locales.

In conjunction with the Edward E. Whitacre Jr. College of Engineering Operations Center, campus tours for students in T-STEM designated schools and non-T-STEM schools are planned and hosted on a frequent basis. Tours include an engineering activity such as building ‘blinky- bots,’ and meeting/interacting with undergraduate students, graduate students, faculty, and staff. A favorite part of the Texas Tech University tour is the Recreation Center where students tour the facility and have opportunities to participate in activities.

OBJECTIVES

1. Transportation focused teacher professional development workshops were aimed at preparing teachers to educate and inspire students to pursue rigorous and rewarding careers in the industry. Broader impacts are achieved when teachers utilize the curriculum on a consistent basis across school years and ultimately when students graduate with majors/degrees directly related to transportation industry workforce needs or move into the career field directly from high school.
2. The teacher professional development workshops were designed utilizing an existing research model; maintaining confidentiality, unidentifiable information was obtained from teachers and administrators to collect data on grade level and subject matter, students per grade, demographics, and number of students per content area.
3. To gather data for reporting and support of STEM education research, before and following professional development workshops, teachers were informed and surveyed through voluntary completion of pre- and post-tests to determine significant gains in knowledge.

4. Results were reported semi-annually to the Texas Education Agency (TEA) and annually via the federal Math/Science Partnership Report.
5. Specific to transportation workforce preparation during the Student Outreach portion of the project, the STEM Student Outreach and Recruitment tours and activity for grades 6 -12 complement curriculum and project-based learning modules educators have taught during the school year.
6. Transportation engineering related activity and tours aimed to build on the real world, inquiry-based curriculum to educate, create exposure, and increase the likelihood for recruiting students into college/university majors and career fields in the transportation industry. An additional goal for outreach and recruitment tours and activity included further narrowing student interest in a specific college and career field within the transportation industry.
7. Working in partnership with the Engineering Operations Center, targeted College of Engineering undergraduate student recruitment also occurred, specifically for junior and senior students.

SCOPE

Science, Technology, Engineering, and Mathematics (STEM) and career technology education (CTE) focused teacher professional development workshops are hallmarks of the Texas STEM Coalition. Under SPTC project 14.1-01, the Texas Tech T-STEM Center (Center) developed curriculum meeting the Texas Education Agency's (TEA) Texas Essential Knowledge and Skills (TEKS) standards in STEM disciplines to provide two teacher workshops that instructed teachers on how to integrate transportation disciplines and issues into their lesson plans. Designed around critical current and future transportation issues, the rigorous curriculum, and innovative teaching strategies were introduced to public/charter/private school teachers during the workshops and provided electronically through the T-STEM Center website afterward. Following both workshops, targeted emails were sent to STEM discipline teachers in the service area for Education Service Centers Region 14, 15, 16, 17 and 18, representing more than 250 public school districts plus charter schools, private schools, and home-school networks. A third event, in conjunction with Texas Tech University's Explore Engineering camp, saw members from TTU's Transportation Leadership Council (the TTU chapter is called TechFLT, Tech Future Leaders in Transportation) presenting topics related to transportation to high school juniors and seniors interested in engineering careers.

Professional development provided to teachers engenders broader impacts, positively affecting current and future students, and by extension economic development for communities and the global economy for years to come.

As a natural outcome of these teacher development workshops, student recruitment and outreach were targeted to 6th to 12th-grade students enrolled in classes taught by teachers who have participated in the Transportation Series workshops. To reinforce teaching and learning modules and lend opportunities for further research and inquiry of students' project-based learning efforts, students can experience educational tours that include hands-on activities closely related to transportation research topics being explored by Civil, Environmental and Construction Engineering faculty Co-Principal Investigators. Other goals of the workshops included sparking interest, providing faculty with student discussion sessions, and solidifying student plans for college and career aspirations toward study/majors and careers in the transportation industry. Designed around critical current and future transportation issues, the teacher professional development workshops featured rigorous curriculum and innovative, effective teaching strategies introduced to public/charter/private school teachers. Educators were expected to utilize the

curriculum during the fall school session so that students participating in transportation projects can extend and supplement their learning on a university campus, interacting with faculty, graduate and undergraduate students and professional staff.

TASKS

Task 1. Teacher Development Workshops

Ms. Cathy H. Allen, Senior Director of Texas Tech T-STEM Center, was the principal investigator of SPTC research project 14.1-01 “STEM Teacher Professional Development – Transportation Series/Student Outreach and Education,” and she was assisted by the Co-PIs Drs. Hongchao Liu, Priyantha Jayawickrama and Sanjaya Senadheera, all faculty members in the Department of Civil, Environmental and Construction Engineering. Workshops were conducted by Ms. Cathy H. Allen of the Texas Tech T-STEM Center along with Dr. Wesley Kumfer (postdoctoral research fellow), Dr. Sangwook Bae (Assistant Professor), Dr. Hoyoung Seo (Assistant Professor), Dr. Sanjaya Senadheera (Associate Professor), and Ph.D. students Tharanga Dissanayake and Manil Hettiwatte, all from the Department of Civil, Environmental and Construction Engineering. In addition to the lead Civil, Environmental, and Construction Engineering faculty researchers, Greg Burnham, master Physics teacher, helped to facilitate the workshops.

During this workshop, teachers received:

- demonstrations on cutting-edge transportation research in formats applicable to instructional techniques for use in their science and math classrooms;
- a deeper understanding of how transportation infrastructure is designed and built;
- a sneak-peek at the future of transportation infrastructure landscape;
- instructional content on highway design and performance, driver behavior, traffic safety and future of surface transportation;
- project-based learning exercises related to sight distance, space between successive vehicles, horizontal and vertical curves, traffic safety, pavement design and material selection, earth-retaining structures and the future of surface transportation;
- materials in transportation infrastructure for math, physics, chemistry, technology and ecology lessons, and
- “hands-on” projects that can be differentiated for the classroom.

A flyer advertising the workshops is shown in Appendix A.

Workshop 1

The first Teacher Professional Development Workshop, a two-day collaboration between the Edward E. Whitacre Jr. College of Engineering faculty in the Department of Civil, Environmental, and Construction Engineering, the Southern Plains Transportation Center, and the Texas Tech University T-STEM Center was held on the Texas Tech University campus on July 12 and 19, 2014.

Eight high school, middle school and elementary math and science teachers from Lubbock and the surrounding area participated. Teachers traveled from Olton, Texas, one hour north of Lubbock, to as far away as Presidio, Texas – in the Rio Grande, located on the Texas/Mexico border – about six hours south of Lubbock. The participating teachers serve elementary, middle, and high-schools in math and science classes plus Pre-calculus, Geometry, Algebra 1, Algebra 2, Physics, IPC, Dual Credit Algebra, Trigonometry, SAT Prep, Social Studies, Robotics, and Math Models. Data collected by the Texas Tech T-Stem Center shows that a total of 743 students are reached by these eight teachers. A demographic breakdown of 53.3% Hispanic, 39.7% White, 3.6% African American, 1.3% Asian and 1.5% from two or more races, with 51.5% of all students classified as economically disadvantaged.

Each teacher also received a stipend to cover partial travel costs incurred.

A lesson plan template that was provided to workshop participants is shown in Appendix B.

Figure 1 shows instructors delivering hands-on activities to integrate transportation design into their classroom lessons.



Figure 1. Texas Tech faculty deliver hands-on projects that teachers can integrate into their classroom lessons

Workshop 2

The second Teacher Development workshop was held on July 28-29, 2015. The workshop focused on transportation research based on faculty research topics including infrastructure design and build; a preview of the future of the transportation infrastructure landscape; instructional content on highway

geometric design, driver behavior, traffic safety and future of surface transportation; project-based learning exercises related to sight distance, space between successive vehicles, horizontal and vertical curves; materials in transportation infrastructure for math, physics, chemistry, technology and ecology; and hands-on projects that can be differentiated for the classroom. In addition to the lead Civil, Environmental, and Construction Engineering faculty researchers, Greg Burnham, master Physics teacher, and previous Summer 2014 workshop facilitator, again helped to facilitate the workshop.

Thirteen teachers enrolled initially, with eleven participating in the two-day workshop. Representing four junior high/middle schools and eight high schools, teachers collectively reach approximately 900 students during a school year. Forty-eight percent of those students are from households that are economically disadvantaged, 57% are Hispanic, 38% are White, 3% African American, 2% Asian, 1% American Indian, and less than 1% identify as Two or More Races/Ethnicities. Courses taught by teachers include Technology, middle school Science, Biology, Physics, IPC, Algebra 1, Algebra 2, Geometry, Math Models, Pre-Calculus, Engineering, ELA, Social Studies, Calculus, Chemistry, Anatomy and Physiology, Special Education, and Advanced Animal Science. Each teacher also received a stipend to cover partial travel costs incurred.

Figure 2 shows hands-on workshop activities that teachers can use in their classrooms to introduce the concepts behind transportation design and engineering.



Figure 2. Summer 2015 Teacher Development Workshop

Task 2. Student Outreach and Education

Task 2 of this project met with several significant challenges and setbacks. Minor strategic and calendar issues frequently arise with attempting to schedule school day trips for students. Tours were originally planned for February and March 2015. These tours were to include tours of the Texas Tech Edward E. Whitacre College of Engineering and educational activities to engage students in transportation engineering. Because of conflicts with the schools' calendars, the tours were rescheduled for May 2015.

Due to extenuating circumstances/family emergency and conflicts with state testing schedules for the schools involved, the student engineering tours and educational activities, tentatively rescheduled for May 2015, were not held. Instead, four student engineering activity dates were scheduled for June 15, 16, 29, and 30, 2015. Titled 'Texas Tech Transportation Futures Workshop,' the planned schedule for each day was the same, including a two-hour time slot of interactive transportation engineering activities developed around autonomous vehicles, robotics, and climate; another 45 minutes of Texas Tech University activity, included an Admissions Office tour/presentation, Recreational Center visit, and lunch in a dining hall. Students and teachers targeted were local education agency consortium members, led by Lubbock-Cooper ISD (other school districts in the consortium included O'Donnell ISD, Wilson ISD, Anton ISD, Brownfield ISD, and Lamesa ISD). Developing the schedule and presentations resulted from collaborations with transportation faculty researchers, Engineering post-doctoral graduate students, and management of the Edward E. Whitacre, Jr. College of Engineering's Engineering Opportunities Center. However, as of the June 10, 2015, deadline, no participation RSVPs had been received. Discussions with Lubbock-Cooper ISD representatives indicated that students were solely responsible for their travel/transportation to the Texas Tech University campus, which caused the lack of response. As a result, the activities were canceled, with plans to host the same activities in mid-September 2015 and early October 2015. Schools invited included the Lubbock Cooper ISD consortium and teachers who participated in the Transportation Engineering professional development workshop held in July 2015.

In July 2015, the Texas Tech T-STEM Center, along with six other T-STEM Centers across Texas, learned that they did not receive federal grant funding for FY 2015-2016. As a result, the Texas Tech T-STEM Center was closed effective August 31, 2015. Cathy H. Allen, the T-STEM Center Director and Principal Investigator of this project, accepted a new position with the Texas Tech University Health Sciences Center. Although she believed strongly in Project 14.1-01, new job duties were not conducive to devoting the quantity and quality of time required to effectively administer the teacher development workshops, not to coordinate the student transportation tours and activities.

In July 2016, TechMRT researchers and graduate students participated in Explore Engineering. The Explore Engineering camp provides an opportunity for high school juniors and seniors to spend a week learning about the Whitacre College of Engineering at Texas Tech University. Participants were introduced to each engineering discipline, participated in hands-on activities, and went on field trips to local engineering facilities in Lubbock. The TechMRT student organization TechFLT organized events related to transportation engineering for the campers.

Dr. Wesley Kumfer presented the topic, "Transportation Safety and the Future of Our Roads," to the students. Following the presentation, TechFLT faculty advisor Dr. Hoyoung Seo, along with organization members Manil Hettiwatte, Tharanga Dissanayaka, Suranga Gunerathne, Bradford Catalano, and Dalton Menn worked with campers to program Lego cars to simulate automated vehicles, and two remote-control cars to simulate human-driven vehicles. The campers made and programmed the Lego cars to drive on a specific path without engaging in obstructions, and then attempted the same maneuvers with the remote-control cars. A total of eleven students participated from the Lubbock, Dallas, Austin, and Houston areas.

Figure 3 shows TechFLT members interacting with high school students at Explore Engineering.



Figure 3. TechFLT members demonstrating hands-on activities to high school student campers at Explore Engineering

Task 3. Teacher Follow-Up

Communication with teachers attending the summer 2014 transportation workshop continued into the following year, specifically related to determining the most convenient date for student tours and interest and availability for a spring 2015 teacher professional development workshop focused on transportation. The Texas Tech University T-STEM Center staff has regular email and phone communication with educators who have attended all Summer 2014, Fall 2014, and Spring 2015 professional development workshops. Teachers and school administrators are instrumental in providing input, especially for determining the exact dates, for planning and hosting student transportation engineering tours and activities.

Communication with teachers attending the Summer 2015 transportation workshop focused on ensuring receipt of professional development continuing education certificates, stipend payments, and future resources for teacher professional development after the T-STEM Center's closure.

ANALYSIS AND DISCUSSION

The Texas Tech T-STEM Center used workshop pre- and post-tests to assess the effectiveness of teacher learning and these are designed to meet compliance requirements of the Texas Tech University Human Research Protection Program (HRPP) protocol/policy. Also, the Teacher Professional Development Workshops pre- and post-tests are designed to be content-specific based on learning objectives for each workshop. Data showed that the transportation workshop participants achieved an 81.8 percent significant gain in learning. In all Teacher Professor Development Workshops conducted by the Texas Tech T-STEM Center in the 2014-15 year, a total of 516 teachers completed various workshops, 491

teachers achieved significant gains in knowledge illustrated by a 95.2 percent aggregate significant gain indicator.

Pre- and post-workshop tests are shown in Appendix C and Appendix D, respectively.

Course and instructor evaluations provided by the trainees (teachers) provided valuable insights on the effectiveness of the second workshop, and these are summarized below. Overall, the evaluations were very positive with particularly overwhelming positives seen of the faculty who conducted the training.

Teacher ratings for course design:

- Course description accurately reflected the topics covered – strongly agree (9), agree (2);
- Course objectives were stated – strongly agree (8), agree (3);
- Length, of course, was adequate – strongly agree (7), agree (4);
- The course content met my needs – strongly agree (5), agree (6);

Teacher ratings of the faculty trainers:

- Trainer was well prepared – strongly agree (11);
- Content was presented in an organized fashion – strongly agree (8), agree (3);
- Content was presented clearly and effectively – strongly agree (10) and agree (1);
- Trainer was responsive to questions/comments – strongly agree (10), agree (1);
- Teaching aids/audiovisuals were used effectively – strongly agree (8), agree (3);
- Teaching style was effective – strongly agree (10), agree (1); and,
- Content presented was applicable to my subject/grade level – strongly agree (7), agree (4).

Some general comments about the workshop:

- “I gained one or more specific ideas that I can implement in my classroom.” (9)
- “I learned a new approach to teaching the subject/content.” (5)
- “It will benefit my students by providing them a better level of understanding.” (7)
- “I acquired new and/or advanced skills.” (8)
- “I have a better knowledge of the subject and teaching methods.” (6)
- “I was able to update my skills.” (4)

Evaluations for the 2014 and 2015 Transportation Engineering and Project Based Learning workshops are shown in Appendix E and Appendix F, respectively.

COST INFORMATION

Costs incurred during this project were for materials and supplies needed to conduct the workshops, stipends for the participating teachers, food for students attending Explore Engineering, fee for workshop facilitator, and salary for a student assistant who worked part-time on the project.

Matching funds on this project was made up of salary for two graduate research assistants and one undergraduate student assistant, all TechFLT members who were active in developing activities for the teacher workshops, and lead activities for the Explore Engineering camp. The original source of these funds was TxDOT sponsored project 0-6747, Seal Coat Quality: Does Low Cost Mean Low Quality?

CONCLUSIONS AND RECOMMENDATIONS

The Teacher Professional Development and Student Outreach Workshops in Transportation Engineering, which was developed and conducted at the Texas Tech T-STEM Center by researchers and educators from the Department of Civil, Environmental, and Construction Engineering, was shown to be a success. There is quantitative evidence to show significant improvement in teacher understanding and interest in transportation-related topics that allows the incorporation of content in a variety of subjects in the grades 6-12 target group. These subjects include, but are not limited to mathematics, physics, economics, energy, psychology, social studies, technology, and design. The transportation engineering modules developed in this project are ready to be implemented on a larger scale that would help promote the area of transportation that is vital to the national economy. The professional development and student outreach activities will also motivate the growth of tomorrow's transportation workforce.

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