Transportation Engineering Advancement and Mentoring Program Phase I

By

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16. Abstract

The numbers of female and minority students enrolled in engineering schools are increasing slowly; however, there are still relatively small percentages drawn to the field of transportation civil engineering. As a consequence, there is a need to educate young people about the profession to encourage individuals from under-represented groups to appreciate the contributions of engineers to society and encourage them to become civil engineers. This summer institute project consisted of bringing middle-school students, after recommendations by their teachers, to the University of Alabama in Huntsville campus to learn about engineering as a career and to experience a variety of transportation-engineering design topics. The participants gained knowledge about the role of engineers in society and learned how engineers use their knowledge in design applications. An additional program was held this year in which the instructors visited local schools during engineers' week to promote the design build challenge held at the university in the fall. UAH female faulty members and professionals from the Society of Women Engineers acted as team mentors.

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Contents

List of Tables

List of Figures

Executive Summary

The numbers of female and minority students enrolled in engineering schools are increasing slowly; however, there are still relatively small percentages drawn to the field of transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage individuals from under-represented groups to appreciate the contributions of engineers and to encourage them to become civil engineers.

The Transportation Engineering Advancement and Mentoring (TEAM) Program is a hybrid of a past UA Huntsville/UTCA summer program (Leonard, *et al.* 2000), with the addition of school visits to science classes. This summer institute project consisted of two programs. The first was similar those of previous years where twenty middle-school students were invited to the University of Alabama in Huntsville (UAH) campus to learn about engineering as a career and to experience a variety of transportation-engineering design topics. The strategy of this program was aimed at producing students who know "how to find out" and "how to examine and evaluate evidence." The four-day summer campus visits included new alternative energy technologies and more personnel from under-represented groups to further highlight the role of mentors.

The second program was a school visit and transportation-engineering challenge for middle-school classes held on campus. Mentors (students and professionals) made visits to local middle-school science classes for one-on-one time. The first visit coincided with national engineers' week in February and culminated with a design build competition during a campus visit day in the fall. The hands-on activities were developed in a previous UA Huntsville/UTCA grants program (Leonard, *et al.* 2000).

The participants gained knowledge about the role of engineers in society and learned how engineers use their knowledge in design applications. The participants also used real-world examples and new technologies in their activities to assure that sustainability would be applied whenever possible.

Section 1
Introduction

Problem Statement

Objectives

There have been major changes in the United States in the past several decades in terms of both the economy and the population. The economic base has shifted from manufacturing durable goods to analyzing information. In this information-driven economy, the most valuable assets are human resources (NCEE 1998). However, the numbers of female and minority students in engineering have reached plateaus. Specifically, there are still relatively small percentages drawn to the field of transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage individuals from under-represented groups to become engineers. The major goal of this program is to introduce middle-school and first-year high-school students to basic engineering and transportation-related concepts through interactive learning activities.

Approach

The major goal of this program was to introduce middle-school students, especially those from under-represented groups, to basic engineering and transportation-related concepts. The project also sought to draft local minority and female engineers to act as team instructors and mentors. Participants used real-world examples and new technologies in hands-on activities to reinforce the concepts presented by the engineering mentors. A final comprehensive team project was used to tie all the knowledge together in a design competition.

Section 2
Background

Purpose

There is growing concern that the United States is not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (STEM) (CSMEE 1983). In past years, the University of Alabama at Huntsville (UAH), in cooperation with the American Society of Civil Engineers (ASCE) and the Society of Women Engineers (SWE), worked with schools in the area. They learned that some schools lacked interaction with engineering technology and professionals. In addition, Madison County schools had a high ratio of minority students: approximately 25% of total enrollment. The Transportation Engineering Advancement and Mentoring (TEAM) Program was created to fill the need in local county and private middle schools. TEAM participants would gain knowledge about the role of transportation planning, management, safety, and design in modern society. Instructional and interactive experiences developed under past University Transportation Center for Alabama (UTCA) grants would travel to reach a larger audience of middle-school students.

Results of previous surveys revealed that students became interested in engineering and the physical sciences after completing the program. Each program faculty member developed activities that encouraged the students to become actively involved in transportation engineering. A pre-survey and post-survey of the participants were performed to quantify attitude and career-interest changes due to the program.

Section 3
Methodology

In past years, UAH and ASCE worked with local schools in the Huntsville, Madison County, and Morgan County areas and learned that local middle schools lacked formal relationships with the academic or technical engineering communities. In addition, those school systems had a high ratio of minority students: approximately 25 percent of total enrollment. Local county middle- and science-magnet-school principals and teachers were asked to nominate students for this Summer Institute. Students from under-represented groups – females and minorities – were given preference. This Summer Institute project consisted of bringing select middle-school students to the UAH campus to learn about various aspects of engineering and to experience transportation-related design and safety topics. A committee of representatives from each participating group, (e.g. academia, professional societies, and K-12 education) ranked and selected the participants based on potential rather than classroom grades. In previous summer institutes, students were selected on their interest and performance.

Program Strategy

Recent efforts to reform science education have led to the development of the Science/Technology/Society (STS) teaching method. Under the STS method, students must feel a concept is personally useful for solving specific problems and students who learn through experience will better retain information and apply the information to new situations. Alabama has adopted instructional policies to ensure students are actively engaged in the learning process, have opportunities for interaction with the environment, and have time for reflection upon learning. Members of the Science State Course of Study Committee and Task Force support the use of inquiry-based instructional models such as the Five E Instructional Model shown below (Armstrong). We have incorporated the following Alabama guidelines in the program:

- **E**NGAGE
  Provide students with activities such as brainstorming and Know, Want to Know, Learned (KWL), as well as make simple observations to stimulate interest, to evaluate and connect past and present learning, and to identify prior misconceptions
- **E**XPLORE
  Allow students to build on prior knowledge through new experiences that incorporate active participation in a range of activities, including analysis, reflection, and data collection
- **E**XPLAIN
  Provide students with opportunities to construct meaning by verbalizing understanding of activities, making explanations, addressing questions, correcting misunderstandings, and introducing new science vocabulary

- **E**XTEND
  Offer students challenging opportunities to practice skills and extend understanding through research, projects, and presentations
- **E**VALUATE
  Have students reflect on their own learning in conjunction with teacher evaluations and self-assessment of understanding

Instructional and interactive experiences were developed to motivate interest in transportation engineering and related science topics as part of the Gearing Up for Transportation Engineering Summer Program (GUTEP) in 2000 (Leonard, *et al*. 2000). The current program contains refined laboratory activities and begins an alumni program to keep participants' interest levels high.

The strategy of this program was to produce students who know "how to find out" and "how to examine and evaluate evidence." As discussed in Leonard, *et al.* (2000), the following criteria were used in designing the hands-on experiments:

- The students could complete the experiments themselves. The experiments were not demonstrations performed by the instructors for the class.
- The students had to be able to read, perform, and document the experiments themselves with limited adult supervision.
- Each experiment was designed such that the results were sufficiently dramatic to keep the student's attention with a high probability of success.
- Middle-school students work best in teams, so the activities and equipment were appropriately structured.
- In general, each experiment took approximately 1-1.5 hours including set-up and clean-up. Follow-up discussions were held to highlight concepts and results.
- Safety and good lab protocol were practiced and stressed throughout.

To accomplish these goals, students were encouraged to use the following design heuristic in their team transportation problem:

1. Define the problem
2. Generate possible solutions, using brainstorming and other creative thinking techniques
3. Decide on a course of action
4. Integrate the solution
5. Evaluate the solution

This project meets *UTCA* goal of increasing diversity in the transportation field and thus affects Alabama's future human resources using technology transfer through focused educational activities.

Section 4
Project Results

Tasks Completed

This project had a one-year duration commencing January 2009. The following tasks were completed to achieve the desired goal of transportation education through technology transfer:

1. E-Week Visits
   Letters were sent to local middle schools to introduce the project and have them sign up for school visits. The PI and college students visited several local schools during National Engineers' Week (February). A presentation on transportation engineering was formulated for these visits and the transportation-engineering challenge was introduced. The teacher was given supplies for the bridges and solar car projects.
2. TEAM Summer Institute (June 15-19, July 20-23)
   The committee selected 30 students for summer program based on potential and interest. The PI contacted professional organizations (National Society of Black Engineers, Society of Women Engineers, and American Society of Civil Engineers), interested college students, local companies, and the Huntsville Center of the US Army Corps of Engineers. The instructors held a meeting to schedule and discuss labs. The PIs met several times to discuss the objectives of each lab experience and to develop individual experiments. Two new labs were developed for 2009: making bio-fuel and building a hybrid-powered automobile. In early June the laboratory instructions were finalized and lab supplies, awards, and t-shirts were ordered. The two sessions (four days each) were held in June and July.
3. Fall Transportation Engineering Design Build Competition
   The classes attended challenge day on campus in October. They took a tour, met practicing engineers, and participated in contests. Winners received pizza parties, t-shirts, and ribbons. A press release was prepared by university relations. Over 100 students participated in the event.
4. Assessment
   To see whether the program had any influence on participants' career choices, a pre-survey was given. The results will serve as the baseline for another survey five years later.
5. Technology Transfer Activities
   A civil-engineering student supported by this contract designed a TEAM web site (http://www.cee.uah.edu/ceek-12outreach/index.html). This allows parents and teachers to see different aspects of the program. Also a technical paper was prepared for an upcoming ASCE education conference.

Synopsis of Curriculum

- Space Transportation
  - *Objective*: To demonstrate how rocket lift-off is an application of Newton's Laws of Motion. Students will also learn about the history and future of space transportation in the US (NASA 2000).
  - *Description*: Students construct a rocket powered by the pressure generated from an effervescing antacid tablet reacting with water. Students also use the NASA disk "Space Transportation: Past, Present and Future" to learn about space applications.
- Construction Materials
  - *Objective*: To learn about different types of materials used for roads, bridges, parking lots, dams, and buildings.
  - *Description*: Students will prepare and test some of the materials used for these infrastructural items, such as wood, metal, concrete, pavement, and composite materials.
- Engineering Shapes
  - *Objective*: To learn how to enhance the strength and stability of simple structures.
  - *Description*: Students will build and test a column, dome, and truss and make predictions on loads.
- Alternative Energy
  - *Objective*: To explore alternatives to fossil fuels for future transportation modes**.** Also, to stress the importance and effectiveness of alternative energy sources.
  - *Description*: In this activity, students will perform experiments using a solar cell. They will observe the physical power of light/heat absorption through a small free-moving device using black and white panels. Each student will construct a battery-powered fan boat.
- Bridges
  - *Objective*: To learn about different types of bridges by building simple models.
  - *Description*: In this activity, students construct a simple span bridge. They will use an interactive computer simulation model to design a suspension bridge to carry the load of a truck. They will also build a scale model of their bridge design.
- Biofuel - Sustainability
  - *Objective*: To understand the principles of “green” fuels and how they can be produced from waste products.
  - *Description*: Students will perform simple experiments in the UAH Chemical Engineering Laboratory to convert vegetable cooking oil into biodiesel fuel.
- Transportation Safety
  - *Objective*: To explore issues related to automobile safety and to explore car-safety designs.
  - *Description*: In this activity, students will learn about bike, bus, and auto safety. They will also perform experiments illustrating passive and active safety features using eggs.
- Robotic Car
  - *Objective*: To learn about new technology that can be adapted to transportation to increase safety and performance.

- *Description*: Each team of two students will build, program, and test a robotic automobile.

- Future Transportation Design Problem
  - *Objective*: To design and build a working model of the team's vision of a future transportation vehicle.
  - *Description*: In this activity, students will design a prototype of a vehicle of the future. They will construct a working model with a motorized K'nex kit to meet energy, safety, and infrastructure constraints. The team will deliver a presentation that illustrates their objectives, approach, and selection of "best" alternative of a future vehicle to the class and to the parents in the last afternoon.

Goals Met

The major goal of this program was to introduce middle-school students, especially those from under-represented groups, to basic scientific and engineering concepts. These groups have potential for science and engineering, but might lack role models and motivation to pursue a career in transportation engineering. The selection committee used the teacher references to rate the students (criteria were student statements of interest, teacher comments, and ethnicity). Through *UTCA* summer program, we were successful in recruiting 65% minority students (African American, Asian, and Hispanic) and 70% female students for the summer program. The ethnicity and gender breakdown is given in Table 4-1.

Table 4-1. Participants' ethnicities

Week 1	Female	Male	%
African American	6	2	40
Caucasian	5	2	35
Hispanic	1	1	10
Native American	1	1	10
Asian	1	0	5
Total	14	6	100

Significance and Benefits of the Program to Participants

The participants gained knowledge about the role of transportation planning, management, safety, and design in modern society. The emphasis was on how engineers use their knowledge in design applications. The last day of the Summer Institute concentrated on team design in transportation engineering, where they combined the knowledge acquired in the laboratory experiences. A faculty member or professional acted as each team's mentor and helped them prepare an electronic and oral presentation for their design. Students on the winning design team were awarded certificates of accomplishment and gifts at the closing ceremony on Friday. All students received a prize of some kind – from the safety challenge, bridge design, rocket launch, etc. – which helped instill a sense of accomplishment and pride.

Because the middle-school curriculum contains hard science and algebra, which are directly related to engineering, this program enhanced classroom instruction with hands-on experience. In addition, the principal investigators and professionals that acted as team mentors also functioned as role models for minority and female students. This may help to increase the

numbers of these students who will become transportation professionals. The use of UAH minority and women engineering students as lab assistants encouraged them to become involved in the community as professionals.

Advantages for Participants

- fun and enjoyable exposure to science, engineering, and transportation-technology topics
- development of critical-thinking and problem-solving skills
- learn what civil engineers do and what their contributions to society to society are
- meaningful and immediate experimental learning
- fuel for their natural curiosity
- self-directed learning opportunities in team design
- increased self-esteem from completion of institute
- multiple exposures to difficult topics and relationships between transportation issues
- opportunity to learn within academic facilities – may take away fear of technology
- diversity of mentors help students feel comfortable at institute

Assessment of Impacts

The program was intended to be a fun learning experience with a lot of basic information, team building skills, and hands-on laboratory experience with the latest transportation-safety and transportation-management technology. On the last afternoon of the program, the students were asked to complete a survey. All instructors this year were either female or from under-represented groups to reinforce their mentoring roles. Prior to the program, the majority of the students did not have relatives or acquaintances who were engineers, so their knowledge of the profession was limited. Participants were surveyed immediately after the program to determine their attitudes about engineering as a career. The vast majority enjoyed the program and stated that they would consider choosing engineering as a future occupation.

Since this is the tenth year for this UTCA project, we have over 400 alumni, with some ready to enter college. A survey of the alumni from the 2003-2005 programs was conducted to determine whether they have entered engineering or science studies to quantify the impact of this program in northern Alabama. Although the return rate on the surveys was low (15%) due to a lack of current addresses, some general conclusions were made about the program. For example, 89% of the respondents planned to attend college and a majority would study engineering (5/9). Of these five students, two females planned to study civil engineering. Question seven asked about the role the program played in their decision. A majority of participants responded that the program was influential in their decision to choose technical fields. Although we do not have a general cohort statistic from this age and demographic population, it seems our numbers show success in that most of these students are going to college (they would be first-generation college graduates) and the majority are going into a technical field.

Table 4-2. Results of 4-6 year program follow-up survey

Question	#	%
1. Respondent Gender		
male	9	40
female	13	59
2. Are you in high school or college now?		
high school	8	38
college	13	62
neither	0	0
3. Are you attending or planning on going to college?		
yes	22	100
no	0	0
not sure	0	0
4. Are you planning on studying engineering?		
yes	8	38
no	12	57
not sure	2	10
5. If you answered yes to question #4 - What major of engineering are you interested in?		
civil	3	36
chemical	1	13
electrical	0	0
industrial	0	0
mechanical	4	50
other	0	0
6. Are you planning on going into some other scientific or technical field?		
yes	5	38
no	1	8
not sure	3	23
7. Did the UAH summer program help you in making your decision about going to college?		
yes	17	81
no	5	24
not sure	0	0
8. Did the UAH summer program help you in making your decision about going to UAH?		
yes	8	38
no	9	43
not sure – 2 go to UA Tuscaloosa	5	24
Total number of respondents	**22**	**100**

UAH Student Involvement

The project employed four undergraduate student assistants (all minorities or females) to help in designing the projects, documenting plans, setting up the laboratory, and assisting the middle-school participants at the Institute. Two female high-school students who completed two years of the program and who planned to study engineering in college volunteered to help as mentors this year. Other university students acted as laboratory volunteers through the SWE, SCE, and NSBE student chapters.

Section 5
Project Conclusions

Education and Technology Transfer Activities

The summer program and class transportation-engineering challenge exposed over 100 middle schoolers to the career of transportation engineering in a fun atmosphere. Results of the five-year follow-up survey revealed that a significant number of the previous attendees are either in college or plan to attend. Further, 38% are going into engineering, which is a much higher number that the general population of "under-represented groups." This is definitely a success for UTCA.

Additionally, team members used the lab-activity manual (both teacher-instruction and student-activity guides) at school visits. A web page was posted through the UAH and UTCA home pages to allow online access.

A technical paper was written and presented by the PI in the engineering-education division of the 2010 ASCE-EWRI Annual Conference. The manuscript title was "TEAM: Review of a Summer Institute for Increasing Under-Represented Students to Civil & Environmental Engineering."

Research Relevance for and Impacts on Alabama

This project addressed the mission and several major goals of UTCA. In addition to providing educational experiences for minority students within Alabama, the project focused on diversity issues. This program has the potential to affect the future workplace (human-resource issues) because the students may wish to become involved in working on transportation-related safety research at an early age and thus may gravitate toward the profession as they mature. The project also addresses UTCA's technology-transfer goal because student assistants, mentors, and participants were exposed to state of the art technology within the university curriculum.

After the program was finished the students completed a survey. All thought that the program was fun and educational. Most did not know what transportation engineers did prior to coming to UAH and were surprised at the variation. Finally, all would recommend the program to their friends.

Recommendations for Next Program

The survey results will be helpful in composing next year's program. The school outreach for the transportation-engineering challenge will be expanded to new schools to increase the number of students included in this event.

Section 6
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Appendix A
Copy of Program Schedule

Title (coordinator)	**Room**
1. Space transportation - Rockets (Dr Edgar)	TH S208 & outside
2. Robot Cars (Dr Edgar)	TH S208
3. Alternative Energy - Solar cars (Dr Kate)	TH S208
4. Alternative Fuels - Biofuels (Dr Katherine)	EB 125
5. Bridges - (Dr Kate, ASCE)	TH S208/210
6. Transportation Safety (Dr Shams)	TH S208
7. Cars (Dr Dawn)	TH N225
8. Future Transportation (All)	TH N105

Table A-1. Team schedule

	Tuesday	**Wednesday**	**Thursday**	**Friday**
9:00 -10:30	Intro: Team Building	Alt Energy: Build Solar Cars	Transportation Safety	Design Build Future Car
10:30 -12:00	Space Transp: Rockets	Test Solar Cars	Bridges – Computer Design	Future Car
12:00 -12:30	*Lunch*	*Lunch*	*Lunch*	*Presentation*
12:30 - 3:45	Robo Cars	Alt. Fuels: Bio Fuel	Bridges – Building/Testing	Program Assessment

Appendix B
Photos from TEAM 2009

B-1. Participants - TEAM 1

B-2. Biofuel experiment

B-3. Robotic car experiment