

Gearing up for Transportation Engineering, A Summer Institute

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16. Abstract In past years UAH & ASCE has worked with schools in the area and became aware that local public schools do not benefit as highly from the technical community as the Huntsville City Schools. In addition, Madison County schools have a high ratio of minority students, approximately 25% of total enrollment. As a consequence, local county middle and "science magnet" school principals and teachers will be asked to nominate students for this institute. Under-represented students, females and minorities, will be especially targeted. A committee consisting of representatives from each of the participating groups will select 20 participants based on potential rather than classroom grades. This summer institute project consists of bringing selected students to the UAH campus to learn about various aspects of engineering and experience transportation-related design and safety topics. Recent efforts to reform science education in schools have led to the development of the Science/Technology/Society (STS) teaching method. Some important aspects of the STS method are that students must feel a concept is personally useful for solving specific problems and students who learn through an experience will retain information and will be better able to apply the information later to new situations. Instructional and interactive experiences will be developed with this grant to motivate interest in transportation engineering and related science topics. Once the individual projects and full curriculum are developed and tested, the program can also be implemented for on-site school visits. A project deliverable will be a manual detailing all aspects of the program for these visits.		13. Type of Report and Period Covered Final Report/ 01/01/00-12/31/00	
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Executive Summary

The numbers of female and minority students enrolled in engineering schools are increasing slowly, however there is still a relatively small percentage drawn to the field of transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage underrepresented individuals to appreciate the contributions of engineers and encourage them to become civil engineers. This Summer Institute project consisted of inviting 20 middle school students to the University of Alabama in Huntsville (UAH) campus to learn about engineering as a career and experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learn how engineers use their knowledge in design applications. Several University of Alabama system engineering faculty members and Society of Women Engineer (SWE) professionals acted as team mentors. As an important part of this project, local minority and female engineers served as mentors for the program.

Section 1

Introduction

Problem Statement

Objectives

The number of female and minority students has been increasing overall in engineering and science (National Commission on Excellence in Education, 1983); however, there is still a relatively small percentage drawn to the field of transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage underrepresented individuals to become engineers and contribute to transportation technology.

Approach

The major goal of this program was to introduce middle school students from underrepresented groups to basic engineering and transportation-related concepts. An additional approach of the project was to draft local minority and female engineers to act as team mentors. Students used real world examples and new technologies in their 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

Huntsville and Madison County Schools

In past years, University of Alabama in Huntsville (UAH) & American Society of Civil Engineers (ASCE) worked with schools in the Madison County area and became aware that local public schools do not benefit as highly from the technical community as the Huntsville City Schools. In addition, Madison County schools have a high ratio of minority students, approximately 25% of total enrollment. As a consequence, local county middle and “science magnet” school principals and teachers were asked to nominate students for this Summer Institute. Underrepresented students, females and minorities, were especially targeted. A committee consisting of representatives from each of the participating groups selected 20 participants based on potential rather than classroom grades.

This Summer Institute project consisted of bringing selected middle school students to the UAH campus to learn about various aspects of engineering and experience transportation-related design and safety topics. This opportunity may encourage them to consider civil and transportation engineering as a career option and increase diversity of the workforce, a problem in some areas of the country (U.S. DOT, 2000).

Section 3 Methodology

Science Teaching Method

Recent efforts to reform science education in schools have led to the development of the Science/Technology/Society (STS) teaching method. Some important aspects of the STS method are that students must feel a concept is personally useful for solving specific problems, and students who learn through an experience will retain information and will be better able to apply the information later to new situations. Instructional and interactive experiences were developed with this grant to motivate interest in transportation engineering and related science topics. The 2000 Summer Institute was an initial trial run of the concept. The 2001 program will enhance the activities and put the teachers' manual on the UTCA web site. Once the individual projects and full curriculum are developed and tested, the program can also be implemented for on-site school visits. A project deliverable will be a manual detailing all aspects of the program for these visits.

The strategy of this program was aimed at producing students who know “how to find out” and “how to examine and evaluate evidence.” The following criteria were used in designing the hands-on experiments:

- The activities were designed so that the students could complete by themselves; not demonstrations performed by the instructors for the class.
- The students must 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 students' attention with a high probability of success.
- Experience has shown that middle school students work best in teams, so the activities and equipment were appropriately structured.
- In general, each experiment took approximately 1-1.5 hour(s) including set-up and clean-up, and 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

The following list of national science education standards' topics (National Research Council, 1998) and skills was used as a template for the “Gearing Up for Transportation Engineering Program” (GUTEPE) activities. Attention to appropriate skill level was a major factor in the preparation of these activities.

Physical Science

- Motions and forces
- Transfer of energy

History and Nature of Science

- Science as human endeavor
- Nature of science
- History of science

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Develop descriptions, explanations, predictions, and models using evidence

Science and Technology

- Abilities of technological design
- Design a solution or product
- Implement a proposed design
- Evaluate completed technological designs
- Abilities of technological design
- Understanding about science and technology or products

Science in Personal and Social Perspectives

- Science and technology in society
- Populations, resources, and environments

Unifying Concepts and Processes

- Evidence, models, and explanation
- Form and function

Science Process Skills

- Collecting Data
- Constructing
- Inferring
- Measuring
- Communicating
- Making Models
- Interpreting Data
- Controlling Variables
- Investigating

This project meets UTCA goals of increasing diversity in the transportation field, and thus affects Alabama's future human resource population, by using technology transfer through focused educational activities.

Section 4 Project Results

Tasks Completed

This project had a one-year duration commencing January 2000. The following tasks were completed to achieve the desired goal of transportation education through technology transfer.

Recruiting – Sent out letters to schools, made phone calls to science teachers and made follow-up contacts. Got summer program committee together to select 20 students based on potential and interest levels. (Copies of the school letter and student recommendation forms are included in Appendix A.)

Schedule Mentors – Contacted professional organizations (National Society of Black Engineers, Society Women Engineers, American Society of Civil Engineers), interested college students, local companies and Huntsville Center of U.S. Army Corps of Engineers.

Set-up Schedule and Lab Experience –

- a) The principal investigator met several times to discuss objectives of each lab experience and to develop individual experiments
- b) Ran through labs with cadette girl scouts during engineer's week
- c) Finalized laboratory instructions and obtained supplies
- d) Scheduled rooms on campus and field trips

Summer Institute –June 18-25, 2000

- a) Broke up students into five teams of four students to run concurrently in labs
- b) Followed schedule
- c) Last day – had judges and participants give demonstrations and design reports

Deliverables

Completed manual for implementation at school visits – All five investigators were responsible for completing their laboratory experiments. The team members completed the evaluation of the final manual for teachers and students. The final report was completed and sent to UTCA in December 2000.

Synopsis of Student Hands-On Experiments

“Gearing Up for Transportation Engineering Program” (GUTEPEP) was scheduled and ran for one full week on the UAH campus. The mornings were scheduled for the informative sessions, followed by lunch. The afternoon activities were characterized by more "hands-on" experiences, such as design projects and laboratories. The last day concentrated on team building and a "vehicle of the future" design project. Photos from the Summer Institute are included in Appendix B. A summary of each laboratory experience follows and the complete laboratory manual is included in Appendix C.

1. 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.

2. Space Transportation

Objective: To demonstrate how rocket liftoff is an application of Newton's Laws of Motion. Students also will learn about the history and future of space transportation in the USA (NASA, 2000).

Description: To demonstrate how rocket liftoff is an application of Newton's Laws of Motion. Students construct a rocket powered by the pressure generated from an effervescent antacid tablet reacting with water. Students also use the NASA disk "Space Transportation: Past, Present and Future" to learn about space applications.

3. Construction Materials

Objective: To learn about different types of materials used for roads, bridges, parking lots, dams, and buildings.

Description: In this activity, students learn about engineering materials used in transportation, such as wood, metals, concrete, pavements and composite materials. They will prepare and test some of these materials.

4. Surveying

Objective: To learn about different ways to measure distance and make a simple map.

Description: In this activity, students will learn how to use simple ratios to estimate distances. The use of a level and tape will be used to estimate slope. They will also learn how use their stride and a compass to make a simple map.

5. Alternative Energy

Objective: To explore alternative energy sources, other than fossil fuels, for future transportation modes. Also, to stress the importance and effectiveness of alternative energy sources.

Description: In this activity, students perform experiments using a solar cell and test a small solar powered car. They will observe the physical power of light/heat absorption through a small free moving device with black and white panels. Then they will construct a battery-fan powered boat.

6. Magnetic Levitation Design

Objective: To learn about new high-speed rail systems based on magnetic energy.

Description: In this activity, students explore magnets and perform simple experiments to determine magnetic energy. They will also use a MAGLEV model to design a commercial passenger train.

7. *Transportation Safety*

Objective: To explore issues related to automobile safety. Also, learn ways to alleviate unwanted noise near highways.

Description: In this activity, students learn about bike, bus and auto restraint safety. They also perform experiments illustrating air bag physics and sound barrier materials.

8. *Soils and Geotechnical Materials*

Objective: To explore classification of soil types and engineering descriptions of soils.

Description: In this activity, students perform simple soil experiments to determine types of soils and engineering properties.

9. *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 design a prototype of a vehicle of the future. They construct a working model with motorized K'nex kit. It must meet energy, safety, and infrastructure constraints.

Field Trips

Past Modes of Transportation -- North Alabama Railroad Museum

Current Modes of Transportation -- Huntsville Jet port and Intermodal facility

Transportation Engineering -- City of Huntsville Engineering and Sign Shop

Future Modes of Transportation --NASA Marshall Space Flight Center's space station mock-ups

Seminars

History of Transportation Engineering

Team Building Skills

Goals Met

The major goal of this program was to introduce middle school students from underrepresented 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 the UTCA summer program, we were successful in recruiting over 75% female and 55% African American students for the program. The ethnicity breakdown is given in the following Table 4.1.

Table 4.1 Participants' Ethnicity Information

	Female	Male	Percent
Total number	15	5	
African American	8	3	55
Asian	1	0	5
Caucasian	6	0	30
Hispanic	0	2	10

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 the 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 to prepare an electronic and oral presentation of their design. Students in the winning design team were awarded the K'nex kits and all participants received certificates of accomplishment from UAH at the closing ceremony. All the students received a prize of some kind, from the safety challenge, bridge design, solar car races, etc., which helped to instill a sense of accomplishment and pride.

Since 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 that will go on to 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.

The program was intended to be a fun learning experience with a lot of basic information, team building skills, and hands-on laboratory experience of the latest transportation safety and management technology. On the last afternoon of the program, the students were asked to complete a program survey course. Table 4.2 shows the results. The "favorite" experiments were the bridge and alternative energy units. These will remain unchanged in the upcoming program. The least favorite, surveying and soils will be updated with more "fun" dynamic activities.

Table 4.2 Participants' Survey Results

Survey Questions	Results	
1. What was your favorite experiment?	1 st Alternative energy 2 nd Bridges	
2. What was your least favorite experiment?	Surveying Soils	
3. What was your favorite field trip?	Jetport & multimodal facility	
4. What was your least favorite field trip?	NASA space station	
5. Would you recommend this program to a friend?	20 = yes	0 = no
6. Would you attend a similar program again	20 = yes	0 = no
7. Do you feel like the field trips and experiments contributed to your learning experience?	19 = yes	1 = no*
8. Did the program increase your knowledge of what transportation engineers do?	20 = yes	0 = no
9. Would you consider becoming an engineer?	17 = yes	3 = no

* one student didn't like the field trips -- "too hot"

In order to determine if this program had any long-term impact on participants, the alumni will be tracked on a yearly basis for mathematics and science involvement in high school. We also have plans to analyze the number of GUTEP alumni who ultimately become engineering students after high school.

Advantages for participants

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

Student Involvement

The project employed four undergraduate student assistants (both minorities and females) to help in designing the projects, documenting plans, laboratory set-ups, and assist with the participating middle school students at the Institute. Other university students acted as laboratory volunteers through the SWE, ASCE and NSBE student chapters.

Section 5

Project Conclusions

Education and Technology Transfer Activities

The team members completed the lab activities manual (both teacher instruction and student activity guides) for implementation at school visits and for next year's program. A web page is also being prepared that will be accessed through UAH and UTCA home pages to allow on-line access of the manual similar to one at Massachusetts Institute of Technology for older students (MIT, 2000).

Research Relevance and Impacts to Alabama

This project addressed the mission and several of the major goals of the UTCA. In addition to providing educational experiences for minority students within Alabama, thus addressed diversity issues. This program has the potential to affect the future workplace (human resources issues). The students may wish to become involved in working on transportation-related safety research at an early age and thus may gravitate towards the profession as they mature. The project also addresses the technology transfer goal of the UTCA since 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 and all thought that the program was fun and educational. Most of them didn't know what transportation engineers did prior to coming to UAH and were surprised at all the variations. Finally, they would all recommend the program to their friends.

Recommendations for Next Program

The survey results will be helpful in composing next year's summer program. The two least favorite labs will be updated with new material and an additional lab will be added. The importance of snacks for this age group was not known at the beginning of the program. Based on this year's data, it would be beneficial to have a hefty afternoon snack available. On the other hand, an early morning snack was not important.

A comment from the UAH student mentors was that the student participants would like a little bit more free time outside of the building to interact. Thus, a 10-minute afternoon "recess" with snacks will be added to the 2001 program.

Section 6.0 References

- U.S. DOT, Bureau of Transportation Statistics, 2000. *Education and Careers in Transportation*, <http://www.bts.gov/edu/68.html>.
- U. S. National Aeronautics and Space Administration, 2000.
<http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Rockets/>
- National Commission on Excellence in Education. 1983. *A Nation at Risk: The Imperative for Educational Reform*. Washington, DC: U.S. Government Printing Office.
- National Research Council. National Science Standards, 1998.
<http://books.nap.edu/html/nses/html/index.html> National Academy Press, Washington, Alexandria, VA.
- Massachusetts Institute of Technology, Department of Urban Studies & Planning, 2000. *Urban Mode Transit Site*, <http://yerkes.mit.edu/DOT2/Introduction/Introduction.html>.

APPENDIX A
Copies of School Letter and Student Recommendation Form

February 3, 2000

Office of the Principal
Decatur Heritage Middle School
Decatur, AL

Dear School Principal:

The University of Alabama in Huntsville and University Transportation Center for Alabama will be co-sponsoring a summer transportation engineering program for underrepresented (e.g. females and minorities) middle school students this summer. The institute will run for one week (June 19 – 23) on the UAH campus. Students will participate in hands-on experiments, field trips, and have a group design project related to transportation engineering. There is no cost for students and includes lunch and snacks for all five days.

Since we would like your math and science teachers to recommend participants, I would appreciate it if you could forward the attached information to them directly. Please note that we would like to include students who show potential for science and math, not necessarily those with the highest grades. I have also attached some application forms for teachers and students to fill out and return by March 21.

If you need any more information, please feel free to call me at 890-6423 (Days) or 776-4972 (Evenings).

Sincerely,

Kathleen Leonard, Ph.D.
Associate Professor

Enclosure



The University of Alabama in Huntsville

GEARING UP FOR ENGINEERING
A UAH-UTCA SUMMER PROGRAM

Student Participant Recommendation

Student Name _____

Address _____

Home Phone _____

Grade (1999/2000) _____ Age _____

School _____

Gender _____ Race/Ethnicity _____

GRADE POINT AVERAGE _____ (or SAT Math score) _____

Reasons for recommendation:

Teacher Signature

Please return completed forms to (fax 890-6724) or mail:
Dr. Kate Leonard
Civil & Environmental Engineering Department, University of Alabama in Huntsville
Huntsville, AL 35899

APPENDIX B



Figure B1. Photo of program participants.



Figure B2. Photo of Team Design Concept Vehicles.

APPENDIX C
Copy of Teachers' Manual and Student Worksheets