Gearing up for Transportation Engineering, A Summer Institute: Phase VII

By

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16. Abstract

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 civil engineering. As a consequence, there is a need to educate young people about the profession to encourage under-represented individuals 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 experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learned how engineers use their knowledge in design applications. An additional program was held this year in which the alumni were invited back for more advanced research in civil engineering projects. Several UAH faulty members and Society of Women Engineer professionals acted as team mentors. As an important part of this project, local minority and female engineers served as mentors for the program. This was the seventh year of the transportation summer program at UAH.

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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 under-represented individuals to appreciate the contributions of engineers and encourage them to become civil engineers. This summer institute project consisted of two programs, the first was similar to 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 experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learned how engineers use their knowledge in design applications. The second program involved inviting back twelve alumni from previous years to perform more in depth research in five areas of civil/transportation engineering. A follow-up survey was sent to program alumni from 2000-2001 to determine if the program impacted their career choice.

Five UAH engineering faculty members, as well as professionals representing the Society of Women Engineer (SWE), NASA Marshall Space Flight Center, and National Society of Black Engineers acted as instructors for the hands on laboratories. As an important part of this project, several minority and female engineering students served as mentors for the program.

Section 1
Introduction

Problem Statement

Objectives

The numbers 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 civil and transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage under-represented individuals to become engineers and contribute to transportation technology.

Approach

The major goal of this program was to introduce middle school students, with preference to under-represented 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 instructors and mentors. Participants 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

Purpose

In past years, the University of Alabama in Huntsville (UAH) and the American Society of Civil Engineers (ASCE) worked with local schools in the Huntsville, Madison County and Morgan County area and became aware that local public schools do not have any formal relationship with the engineering academic and technical community. In addition, all those school systems have a high ratio of minority students, approximately 25 percent 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. Under-represented students, female and minorities, were given preference. 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. A committee consisting of representatives from each of the participating groups selected these participants based on potential rather than classroom grades.

This year, an additional five days were dedicated to an alumni program for students who had participated previously in this UTCA program. These students were selected based on their interest and performance in the past. 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

Program Strategy

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. Alabama has adopted a policy for effective instructional strategies to ensure that 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 [Alabama Science], as shown in Table 3-1. We have incorporated the following AL guidelines in the GUTEP program.

Table 3-1: Five E instructional model

ENGAGE	Providing students with activities such as brainstorming; Know, Want to Know, Learned (KWL); and making simple observations to stimulate interest, evaluate and make connections between past and present learning, and identify prior misconceptions
EXPLORE	Allowing students to build upon prior knowledge through new experiences that incorporate active participation in a range of activities, including analysis, reflection, and data collection
EXPLAIN	Providing students with opportunities to construct meaning by verbalizing understanding of activities, making explanations, addressing questions, correcting misunderstandings, and introducing new science vocabulary
EXTEND	Offering students challenging opportunities to practice skills and extend understanding through research, projects, and presentations
EVALUATE	Having students reflect on their own learning in conjunction with teacher evaluations and self-assessment of understanding

In previous years, instructional and interactive experiences were developed with this grant to motivate interest in transportation engineering and related science topics. The program was initiated in the Gearing Up for Transportation Engineering Summer Program (GUTEP) in 2000, the current year's program contains refined laboratory activities and initiated 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 the first year's UTCA final report [Leonard, et al., 2000], the following criteria were used in designing the hands-on experiments:

- The activities were designed so that the students could complete them by themselves; 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.

- 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 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

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 2006. The following tasks were completed to achieve the desired goal of transportation education through technology transfer.

Recruiting

Letters were sent to schools, phone calls were made to science teachers and follow-up contacts were made. Dr. Leonard made site visits to several middle schools to meet with science and math teachers for additional recruiting. The program committee met to select twenty students for the initial GUTEP week and an additional twelve for the alumni program based on potential and interest levels.

Schedule Mentors

The principal investigator contacted professional organizations (National Society of Black Engineers, Society Women Engineers and ASCE), college chapters of the societies, NASA Marshall Space Flight Centers, local companies (SEI Group, Boeing and Sverdrup), and the Huntsville Center of US Army Corps of Engineers.

Set-up schedule and lab experience

The following activities were undertaken:

a) The principal investigator met several times with instructors to discuss objectives of each lab experience.
b) Professors were asked to update individual experiments as indicated by last year's survey results.
c) Instructors developed six hour labs for the alumni program: GPS and Surveying (Dr. Anderson), Geotech (Dr. Schwarz), Robotics (Edgar Blevins - ISE), Composite Materials (Dr. Toutanji) and Solar Power (Dr. Leonard).
d) Instructors previewed labs with several middle school students prior to GUTEP.
e) Instructors finalized laboratory instructions from co-PIs.
f) Dr. Leonard obtained supplies and collated student manuals.
g) Dr. Leonard scheduled rooms on campus and field trips.

Summer institute

The institute was conducted June 20-24, 2005.

a) Students were divided into five teams of four students to run concurrently in labs.
b) The institute schedule was followed (see Appendix A).

c) On Friday the participants gave demonstrations and oral reports on their teams' future transportation design to parents and instructors.

Alumni institute

The alumni institute was conducted 20-June 24, 2005.

a) Each instructor took student teams for a day and performed more in-depth projects requiring problem solving skills.
b) Each day ended with a team discussion on topics learned and how they may be applied to transportation engineering.

Après- program

After the conclusion of the institutes, the following activities were conducted:

a) Thank you letters and certificates were sent to instructors and field trip sponsors.
b) Participant surveys were compiled.
c) Instructors met to discuss ways to improve program for subsequent years.
d) The final report was prepared and submitted.

Deliverables

a) Completed manual for students and as a teacher resource – All five investigators were responsible for completing their laboratory experiments.
b) The manual was posted on the UAH UTCA web site in html format (http://coeweb.eb.uah.edu/cee/utca.htm).
c) Principal investigator was responsible for quarterly reports to UTCA. The final report was completed and sent to UTCA in December 2006.
d) Technology Transfer: An abstract was submitted by the principal investigator that was accepted for the 2007 ASEE Annual Conference to be held in summer of 2007.

Synopsis of Curriculum

1. Traffic Simulation

Objective**:** To learn about the traffic engineering concept, level-of-service, and how traffic engineers use micro-simulation to analyze roadway intersections and design city streets.

Description**:** In this activity, students explore traffic micro-simulation and determine existing and future levels of service for different roadways systems. The students will learn about highway design principles related to intersections and traffic signal control.

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 effervescing 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. Engineering Shapes

Objective**:** To learn how to enhance the strength and stability of simple structures.

Description**:** In this activity, students will build and test a column, dome and truss and make predictions on loads.

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. They will observe the physical power of light/heat absorption through a small free moving device with black and white panels. Each student will construct a battery powered fan boat.

6. 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.

7. Geotechnical Materials – Mud Pie Magic

Objective**:** To understand the principles of soil compaction and the behavior of layered soil systems when supporting a dynamically applied load.

Description**:** Students will perform simple experiments in the UAH Soil Mechanics Laboratory to demonstrate the behavior of a layered soil system and load carrying ability of the system for dynamic loadings similar to wheel loads imposed by traffic.

8.Transportation Safety

Objective**:** To explore issues related to automobile safety and to explore alternatives that would design safety into cars**.**

Description**:** In this activity, students learn about bike, bus and auto restraints safety. They also perform experiments illustrating passive and active safety features using eggs.

9. 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.

10. 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 to meet energy, safety, and infrastructure constraints. The team prepares a presentation for the class and parents of the last afternoon that illustrates their objectives, approach and selection of a future vehicle.

Goals Met

The major goal of this program was to introduce middle school students with preference to 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 the UTCA summer program, we were successful in recruiting 45 percent minority students (African American, Asian and Hispanic) and 85 percent female students for the first week. The alumni program was 17 percent female with 67 percent ethnic minority students for the program. The ethnicity and gender breakdown is given in Table 4-1.

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 faulty 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 certificates of accomplishment and gifts at the closing ceremony on Friday. All the

students received a prize of some kind, from the safety challenge, bridge design, rocket launch, etc., which helped to instill a sense of accomplishment and pride.

Table 4-1. Participants' ethnicity information

Week 1	Female	Male	Percent
Basic Institute			
Total number	17	3	100%
African American	6	2	40%
Asian	2	0	10%
Caucasian	7	1	40%
Hispanic	2	0	10%
Alumni Program			
Total number	2	10	100%
African American	1	4	42%
Asian	0	1	8%
Caucasian	1	3	33%
Hispanic	0	2	17%

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 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.

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 concrete bowling (materials) and bridges (design and build Popsicle stick bridge). These will remain unchanged in the upcoming program. The least favorite, space transportation will be updated with more fun dynamic activities. The students were also asked about their enjoyment of the program and most of them answered affirmatively to questions regarding recommending this program to a friend and the fact that the field trips and experiments increased their knowledge of engineering (question #6). The last question indicates their own views about engineering as a future career for them. Approximately 90 percent thought that they might choose engineering as a profession.

Advantages for participants

- fun and enjoyable exposure to science, engineering and transportation technology topics
- development of thinking and problem-solving skills
- learn what civil engineers do and their contributions to society
- 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 exposure to difficult topics and inter-relationships to transportation issues
- opportunity to learn within academic facilities – may take away fear of technology
- diversity of mentors help students feel comfortable at institute

Table 4-2 Participants' survey results

Survey Questions		Responses	
1.	What was your favorite experiment?	Concrete bowling, robotic cars	
2.	What was your least favorite experiment?	Egg drop	
3.	What was your favorite field trip?	HSV depot and railroad museum	
		Yes	**No**
4.	Would you recommend this program to a friend?	95%	5%
5.	Would you attend a similar program again	95%	5%
6.	Do you feel like the field trips and experiments contributed to your learning	90%	10%
7.	Is one (or both) of your parents engineers?	30%	70%
8.	Did the program increase your knowledge of what transportation engineers	95%	5%
9.	Would you consider becoming an engineer?	90%	10%

Five Year Follow up Survey Results

Assessment of Impact of GUTEP

Since this was sixth year for this UTCA institute, there is an alumni-base of over 180 students, with some at college entry age. The alumni from the first three years were surveyed to determine if the past participants have entered engineering or science studies to quantify the impacts of this program in North Alabama. Although statistically significant conclusions could not be drawn because the return rate on the surveys was low (sixty surveys were mailed, but only nine were returned), some general conclusions can be made about the program.

The primary finding of the survey was that it was extremely difficult to trace student actions over time. This was a surprise to the GUTEP staff, but upon reflection it was due to issues like the mobility of their parents, federal legislation protecting student records, changes in teachers working with the program, and other factors. These factors are not likely to change, and conducting longitudinal studies of student advancement over time will probably always be a time consuming and expensive task with limited results.

Table 4-3 shows the responses. For example 89% of the respondents were planning on going to college and the majority was gong to study engineering (5/9). Of these five students, two females were planning on studying civil engineering. Question number 7 asked about the role that the GUTEP played in their decision and the majority did respond that it did. Although we don't have a general statistic from this age and demographic population, it seems that our numbers show success in that most of these students are going to college (they are first generation college graduates) and the majority are going into a technical field.

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. At the conclusion of each year's institute, participants were surveyed 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. Over the six institutes conducted with UTCA funding, an alumni base of over 150 students has been build, with some at college entry age. If the limited data in Table 4-3 is a good estimate for the alumni base, then approximately 33% are currently enrolled in engineering or will enroll. This amounts to 50 engineering students.

Table 4-3: Results, 4-6 year follow up survey

Question		Number	Percentage
1. Respondents Gender			
	Male	1	11%
	Female	8	89%
2. Are you in high school or college now?			
	High school	1	11%
	College	7	78%
	Neither	1	11%
3. Are you attending or planning on going to college?			
	Yes	8	89%
	No	0	0%
	Not sure	1	11%
4. Are you planning on studying engineering?			
	Yes	5	56%
	No	4	44%
	Not sure		0%
5. If you answered yes to question #4 - What major of engineering are you interested in?			
	Civil	2	40%
	Chemical		
	Electrical	2	40%
	Industrial		
	Mechanical		
	Other	1	20%
6. Are you planning on going into some other scientific or technical field?			
	Yes	2	50%
	No	1	25%
	Not sure	1	25%
7. Did the UAH summer program help you in making your decision about going to college?			
	Yes	4	44%
	No	3	33%
	Not sure	2	22%
8. Did the UAH summer program help you in making your decision about going to UAH?			
	Yes	4	44%
	No	3	33%
	Not sure	1	11%
Total Number of Respondents		9	100%

UAH Student Involvement

The project employed four undergraduate student assistants and one graduate student (all minorities and/or 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 Society of Women Engineers, American Society of Civil Engineers and National Society of Black Engineers 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 was posted through UAH - UTCA home pages to allow on-line access.
An abstract was written by the PI and Dr. Edgar Blevins for the upcoming 2007 American Society of Engineering Education Annual Conference, in the "K-12 engineering education" division. The title is "Gearing Up for Transportation Engineering: A Summer Institute for Under-Represented Middle School Students" It was recently accepted for a presentation and publication of a full article.

Research Relevance and Impacts to Alabama

This project addressed the mission and several major goals of the 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 resources issues) since 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 did not 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 least favorite lab will be updated with new material and an additional lab will be added. The new activity, "CE challenge", which was held in the fall for local high school freshman was not as well attended as hoped (only five schools), so we will discuss ways to improve turn-out.

Section 6
References

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APPENDIX A

"GEARING UP FOR TRANSPORTATION ENGINEERING SUMMER INSTITUTE"

2006 SCHEDULE

Field Trips (Thursday)

Past Modes of Transportation

Huntsville Train Depot & Museum – Church St

Current Modes of Transportation

Huntsville Shuttle Service (Mass Transit)

Huntsville Traffic Office – Sign shop, Intelligent Transportation System

Hands-On Sessions (4 Groups of 5 students each)

Title (coordinator)

Traffic Simulation - (Dr. Mike & Pryam)

1. Space transportation - (Dr. Sam & Lulu)
2. Construction Materials -- (Dr. Sam & Lulu)
3. Engineering Shapes - (Dr. Mike)
4. Alternative Energy/Boats (Dr. Kate & Margaret)
5. Bridges - (Dr. Lois & Pryam)
6. Geotechnical Materials --(Dr. Lois & Margaret)
7. Transportation Safety - (Dr. Kate & Pryam)
8. Robot Cars (Dr. Edgar & Margaret)

DAILY SCHEDULE

	Monday 12th	**Tuesday 13th**	**Wednesday 14th**	**Thursday 15th**	**Friday 16th**
9-10	Introduction History of Transportation	Exp 8, 4	Exp 5, 2	HSV Shuttle RR museum	***Concrete BB*** Team Design Project
10-11:30	Team Building	**Exp 8, 4**	Exp 5, 2		
11:30-12	*Lunch - Pizza*	*Lunch – Subs*	*Lunch –* Hamburgers	*Lunch – picnic*	*Lunch – Pizza*
12 -1:45	Exp 3, 7	Exp 1, 6	Exp 9	City Eng.	Design Competition
1:45- 2:00	Break	Break	Break		
2:00-3:45	Exp 3, 7	Exp 1, 6	Exp 9	Break	Awards
4:00	Depart	Depart	Depart	Soccer	Depart

APPENDIX B

4-6 YEAR FOLLOW UP SURVEY

1. How old were you when you participated in the UAH Civil Engineering Summer Camp? _____ age _____ Don't remember

2. Are you in high school or college now?

   ____ high school ____ college ____ neither

3. Are attending or planning on going to college?

   ___Yes ___ No ___ Not Sure

4. Are you planning on studying engineering?

   ___Yes ___ No ___ Not Sure

5. If you answered yes to question #4 - What major of engineering are you interested in?

   ____ civil

   ____ chemical

   ____ electrical

   ____ industrial

   ____mechanical

   ___ other

6. Are you planning on going into some other scientific or technical field?

   ___Yes ___ No ___ Not Sure

7. Did the UAH summer program help you in making your decision about going to college?

   ___Yes ___ No ___ Not Sure

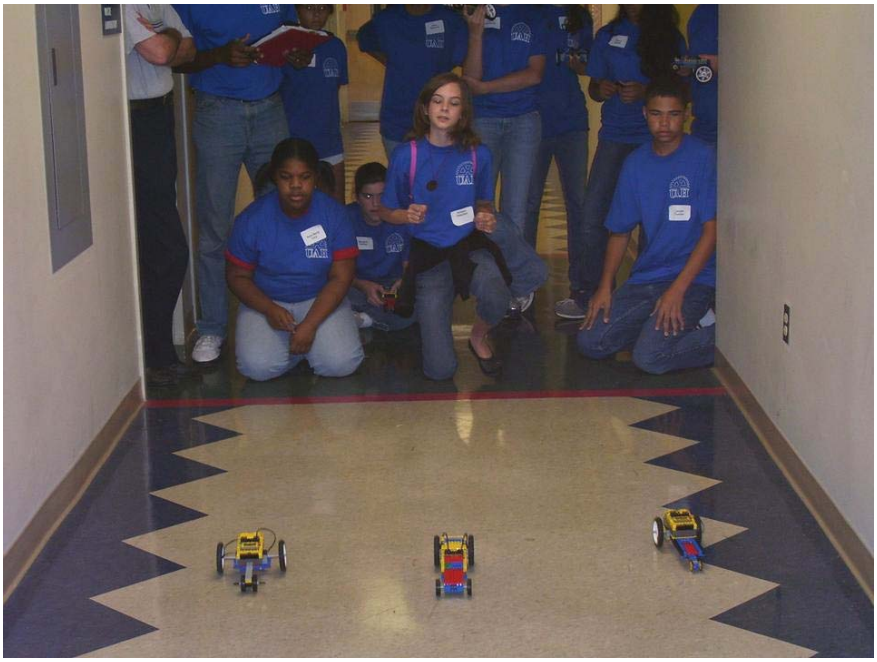
8. Did the UAH summer program help you in making your decision about going to UAH?

   ___Yes ___ No ___ Not Sure

APPENDIX C

C-1: GUTEP participants – week 1

C-2: GUTEP participants – week 2



C-3: Robotic car races