

# **Gearing up for Transportation Engineering, A Summer Institute: Phase V**

By

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**University Transportation Center for Alabama**

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And the University of Alabama in Huntsville

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<b>16. Abstract</b> 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 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. A second program was initiated this year in which the alumni were invited back for more advanced research in civil engineering projects. Several UAH faculty 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 fifth year of the 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-two 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.

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**

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**

### **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 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 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

The following list of national science education standards' topics (National Research Council, 1998) and skills was used as a template for the GUTEP 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, Understanding 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 2004. 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. Dr. Leonard made site visits to several middle schools to meet with science and math teachers for additional recruiting. The program committee got together to select 22 students for the 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, American Society of Civil Engineers), college chapters of the societies, NASA Marshall Space Flight Centers, local companies (SEI Group, Boeing and Sverdrup), and Huntsville Center of US Army Corps of Engineers.

### ***Set-up schedule and lab experience*** –

- 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 new 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) Ran through labs with several middle school students prior to GUTEP.
- e) Finalized laboratory instructions from co-PIs.
- f) Obtained supplies and collated student manuals.
- g) Scheduled rooms on campus and field trips.

### ***Summer institute*** –Week 1: June 21-25, 2004

- a) Divided students into five teams of four students to run concurrently in labs.
- b) Followed schedule (see Appendix A).
- c) Friday of each institute–Participants gave demonstrations and oral reports on their team's future transportation design to parents and instructors.

### ***Alumni institute*** – June 14-July 31, 2004

- 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***

- a) Thank you letters and certificates were sent to instructors and field trip sponsors.
- b) Compiled participant surveys.
- c) Instructors met to discuss ways to improve program for subsequent years.
- d) Proposal was submitted for 2005 UTCA funding.

### ***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 2004.

## **Synopsis of Student Hands-On Experiments**

The GUTEP summer institute for new students was similar to previous years (see previous final reports). A new water-power experiment was added under the supervision of Mr. Bill Byrd, a teacher at Riverton Middle school; it is included in Appendix B. However, the alumni program was completely developed under this grant. A summary of these each laboratory experiences follows. Photos from the Summer Institute are included in Appendix C.

### ***1. Solar Car Design/Build***

**Objective:** To learn about the different components of an automobile and appreciate alternative forms of energy.

**Description:** In this experiment students will learn how to make a model solar car and perform tests to optimize the speed.

### ***2. Robotic and Sensor Applications in Automobiles***

**Objective:** To learn the engineering skills of problem solving, design and computer programming

**Description:** Student teams will design, build and program a robot using LEGO parts and ROBOLAB software. The robot must move cans out of a circle within a two minute time limit.

### ***3. Civil Engineering Materials***

**Objective:** To learn about concrete, wood and other materials that may be used to build bridges; also learn about tension, compression and failure of these materials.

**Description:** In this activity, students will construct a simple span bridge. They use an interactive computer simulation model to design a suspension bridge to carry the load of a truck. Then they build a scale model of their bridge design and test in under increasing loads.

### ***4. Geotechnical Materials and Bridge Building***

**Objective:** To understand how soils behave under different loading conditions and how this affects building of bridges, roads and other structures.

**Description:** In this activity students learn about the behavior of a layered soil system and load carrying ability of the system. This is accomplished for dynamic loadings similar to wheel loads imposed by traffic.

**5. GPS and Map Skills**

**Objective:** To explore the use of GPS and how it can be incorporated into maps and GIS.

**Description:** In this activity, students will use a GPS meter as they hike across campus and then learn how to download the data and make a map of the site. They discuss how this can impact surveying and other aspects of mapmaking.

**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 60 percent female students for the first week. The alumni program was 58 percent female with 60 percent ethnic minority students for the program. The ethnicity breakdown is given in Table 4-1.

**Table 4-1. Participants ethnicity information**

<b>Week 1</b>	<b>Female</b>	<b>Male</b>	<b>Percent</b>
African American	4	3	35%
Asian	0	1	5%
Caucasian	8	3	55%
Hispanic	0	1	5%
Total	12	8	100%
<b>Alumni Program</b>			
African American	3	2	42%
Asian	1	1	16%
Caucasian	3	2	42%
Hispanic		0	0%
Total	7	5	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 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 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.

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 alternative energy (battery powered fan boat) and bridges (design and build popsicle stick bridge). These will remain unchanged in the upcoming program. The least favorite, soils will be updated with more fun dynamic activities. The students were also asked about their enjoyment of the program and all of them answered affirmatively to questions regarding recommending this program to a friend (100 percent said they would attend a similar program next year) and the fact that the field trips and experiments increased their knowledge of engineering (question #7). 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	
What was your favorite experiment?	bridges, alt energy	
What was your least favorite experiment?	Soils	
What was your favorite field trip?	HSV Shuttle bus	
What was your least favorite field trip?	Airport intermodal	
	Yes	no
1. Would you recommend this program to a friend?	100%	0
2. Would you attend a similar program again	100%	0
3. Do you feel like the field trips and experiments contributed to your learning *experience?	95%	5%
4. Did the program increase your knowledge of what transportation engineers do?	100%	0
5. Would you consider becoming an engineer?	90%	10%

***UAH Student Involvement***

The project employed four undergraduate student assistants and two graduate students (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 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.

#### ***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. We will initiate a "CE challenge" to be held at UAH in the fall term where local high school freshman are invited to the campus to compete in a bridge-building contest.

## Section 6 References

- Leonard, K., Toutanji, H., Anderson, M., Delatte, N., and Hodges, J., Gearing up for Transportation Engineering, A Summer Institute, UTCA Report #00-304, 2000.
- Massachusetts Institute of Technology, Department of Urban Studies & Planning, 2000. *Urban Mode Transit Site*, <http://yerkes.mit.edu/DOT2/Introduction/Introduction.html>.
- 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.
- U. S. National Aeronautics and Space Administration, 2000.  
<http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Rockets/>
- U.S. DOT, Bureau of Transportation Statistics, 2000. *Education and Careers in Transportation*, <http://www.bts.gov/edu/68.html>.



**APPENDIX A**  
Sample of Program Schedule

**“GEARING UP FOR TRANSPORTATION ENGINEERING SUMMER INSTITUTE”**

**SUMMER 2004**

**Field Trips**

**Past Modes of Transportation (Wed)**

North Alabama Railroad Museum - Chase, AL

**Current Modes of Transportation (Thurs)**

Huntsville Shuttle Service (Mass Transit)

Huntsville Trans. office – Sign shop, Intelligent Transportation System

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

**Title (coordinator)**

**Room**

- |  |               |
|--|---------------|
| 1. Traffic Simulation - (Dr. Mike & Catalina)  | TH S242       |
| 2. Space transportation - (Vana, Emily)        | TH S208 & 206 |
| 3. Construction Materials - (Dr. Sam & Eugene) | TH S207       |
| 4. Engineering Shapes - (Dr. Mike & Shalana)   | TH S206       |
| 5. Alternative Energy/Boats (Shalana & Emily)  | TH S203       |
| 6. Bridges - (Dr. Lois v& Catalina)            | TH S208       |
| 7. Geotechnical Materials -(Dr. Lois & Eugene) | TH S224       |
| 8. Transportation Safety - (Dr. Kate)          | TH S207       |
| 9. Robot Cars (Edgar & Shalana)                | TH N104       |
| 10. Water Wheel – (Dr. Kate & Catalina)        | TH S203       |

**DAILY SCHEDULE**

	<b>Monday 21<sup>st</sup></b>	<b>Tuesday 22<sup>th</sup></b>	<b>Wednesday 23<sup>th</sup></b>	<b>Thursday 24<sup>th</sup></b>	<b>Friday 25<sup>th</sup></b>
9-10	Introduction Team Building	Exp 3, 4	RR museum	HSV Shuttle service City Eng.	<b>Concrete BB Team Design Project</b>
10-11:30	History of Transport.	Exp 3, 4	Ride		
11:30-12	<i>Lunch – Pizza</i>	<i>Lunch – Subs</i>	<i>Lunch – burgers</i>	<i>Lunch – picnic</i>	<i>Lunch – Pizza</i>
12 -1:45	Exp 2, 7	Exp 9	Exp 5,6	Exp 1, 10	Design
1:45- 2:00	Break	Break	Break	Break	Competition
2:00-3:45	Exp 2, 7	Exp 9	Exp 5,6	Exp 1, 10	Awards
4:00	Depart	Depart	Depart	Depart	Depart

APPENDIX B  
Copy of New Experiment

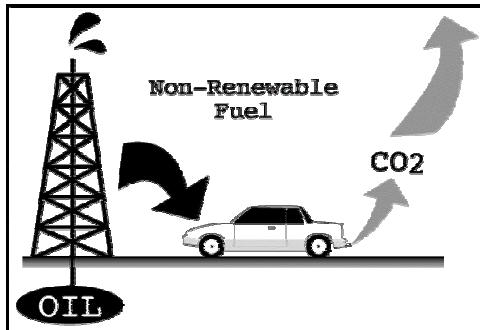
## 5. Alternative Energy = Water Power

### Turing Water into Light 😊

In this activity, you are going to make electricity using waterpower. You will construct a water wheel using K'nex and test it out. Then you will observe the power of water from different heights and changing gear ratios.

**Materials and Tools:**  
K'nex kit with gears  
Board for mounting  
Mounting brackets  
2 gallon pail for water  
Hose to deliver water  
Large rectangular plastic bin to catch water  
Ruler  
Water supply  
Small LED  
Volt meter (if desired)

As the world's supply of fossil fuels is being used up, there is a need for new energy sources. Adding to this need is the fact that the current use of fossil fuels causes pollution in the form of carbon monoxide, unburned hydrocarbons, nitrogen oxides, soot, and particulates. Some of the alternatives that have been suggested are batteries (electricity), hydrogen fuel (fuel cells), solar panels (photovoltaic), ethanol, methanol, natural gas,



geothermal, biomass, hydroelectric, and electric wind generators. Methanol is made from natural gas, while ethanol is made by fermenting crop (primarily corn) starches and sugars.

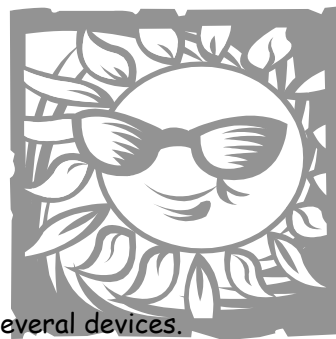
Geothermal energy is created when we force hot steam from the earth. Scientists can also harness the energy from the ocean and its thermal changes; this type of energy is classified as a biomass

energy source. Other, more common types of energy sources are electric wind and hydroelectric generators.

Hydroelectric power uses the potential energy of water

Gears are used to produce power from rotational motion. Different sizes ---

# Instructions



## 5a. Demonstration of Hydroelectric Power

The instructor will demonstrate the potential energy of water using several devices.

1. Look at the "dynamo" and see if you can make it spin fast enough to produce light in the diode.
2. Count the rotations per minute (rpm) then make a note of the lowest rpms on data report sheet

## 5b. Water Wheel Construction

1. Take a K'nex kit and find the gears and main axle for the moving part of the water wheel. (See the picture the instructor will have for an idea.)
2. Identify the vanes and place on the connector
3. Attach the dynamo apparatus to the mounting board and put a gear on the shaft.
4. Make sure that the electrical wires to the diode are in place

## 5c. Operation of your waterwheel

*To operate the waterwheel, you will need to move water from the bucket to the water wheel. Here is way to get the water started:*

1. Fill the bucket 2/3 full with water and set it on the ladder
2. Attach the plastic hose to the nozzle and let it drop to the water wheel
3. Test your waterwheel - hydroelectric power system.
4. Measure the voltage with the multimeter for your first bucket height.
5. Refill the bucket and move to a higher position on the ladder.
6. Measure the voltage and write on the table in your worksheet.
7. Change the size of the gear on the waterwheel and rerun your experiment.
8. Rebuild the water wheel to make it produce more power.
9. Answer the discussion questions.

# 5. Alternative Energy Report Sheet

Group Name ☺ \_\_\_\_\_

## 5a. Power of Water

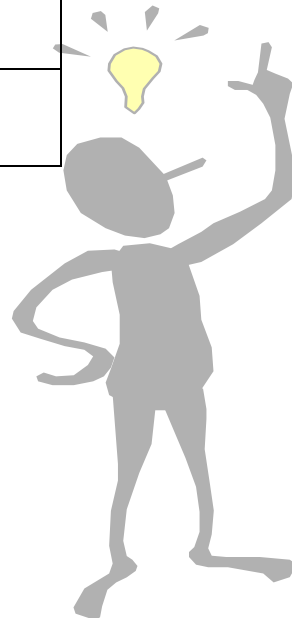
1. What was the rpm required to make the light shine?

## 5b. Water Wheel

1. What was the maximum rpm for each height of the water?
2. Which gear combination worked best?
3. If you change your vanes what will the effect be on the power produced?

Hydroelectric Power Results Table

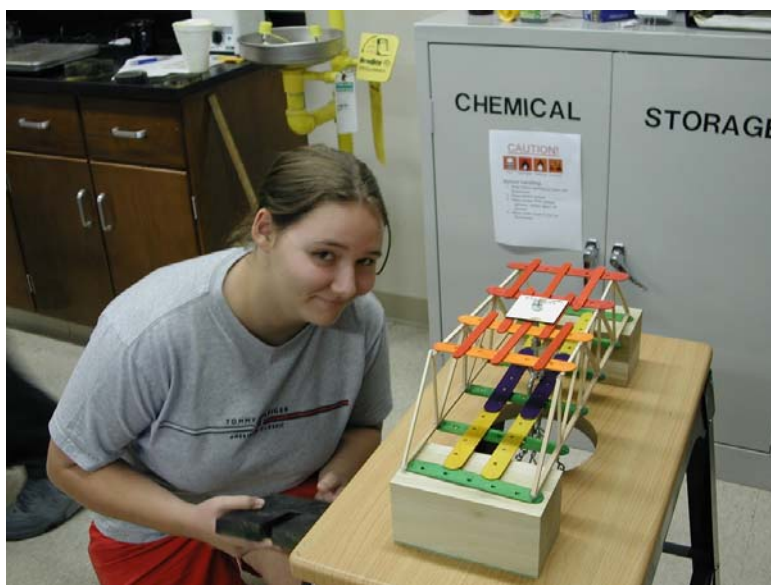
Water Height	Light produced? Yes - No	Voltage	Distance



**APPENDIX C**  
**Photos from GUTEP 2004**



**C-1. Week 1 - robotic cars experiment**



**C-2. Alumni Week – bridge deign/build**



**C-3. Week 1 – water power experiment**



**C-4. Week 1- GUTEP participants**