

# Mississippi Summer Transportation Institute 2007

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**Abstract** – In the summer of 2007, Mississippi State University's Bagley College of Engineering was awarded a grant from the Mississippi Department of Transportation (MDOT) to host the 2007 Mississippi Summer Transportation Institute (MSTI). The MSTI is a three-week residential program for 19 rising high school sophomores and juniors. The focus of MSTI was how science, technology, engineering, and mathematics (STEM) related to transportation and career opportunities in transportation.

The MSTI included hands-on activities, development of communication skills, and utilization of technology and skills required in today's workforce. Field trips to the Nissan plant, Mississippi Department of Transportation (MDOT), and the Columbus, MS Air Force Base exposed students to real-world applications of STEM and introduced them to a wide range of careers in transportation. Curriculum included sessions about structural systems, system illustration (CAD), transportation system layout, hydraulic engineering, environmental and water resources engineering, pavement materials design, building materials design, and traffic management. Leadership training and team building activities were also included.

According to student feedback, there was an increase in interest across all subject areas after their participating in the MSTI. Post-program follow up also suggest that the MSTI had a positive effect on encouraging participating students to take more science and math courses. When asked how MSTI will influence their career choices, some of the participants specifically noted overall desires to become engineers. The more specific comments included, "I will most likely be an engineer and MSTI has helped with that choice." "This camp has enforced my interests in engineering..." "This camp definitely made me want to be an engineer."

This paper will present the overall curriculum of the MSTI camp with specific emphasis on activities that could be implemented at other institutions. In addition, detailed assessment results of each activity will be presented to help institutions interested in implementing similar camps to chose activities which appear to be of most benefit to the students.

*Keywords:* K-12, Transportation

## INTRODUCTION

The Center for Science, Mathematics and Technology (CSMT) and the Bagley College of Engineering (BCoE) at Mississippi State University were recently awarded a contract by the Mississippi Department of Transportation (MDOT) and the Federal Highway Administration (FHWA) to develop and conduct a three-week residential summer institute for rising high school sophomores and juniors. The resulting Mississippi Summer Transportation Institute (MSTI) was developed with several specific objectives. First, we wanted to expose the participating students to science, technology, engineering and mathematics (STEM) as it applies to the transportation and the civil engineering profession. MSTI was also designed to introduce participants to the numerous technical and professional career opportunities that exist in the transportation industry. A third objective was to provide opportunities for the students to develop leadership skills and improve their work ethic.

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Finally, it was hoped that the experience would provide a positive perspective of what to expect when these student attended college.

The MSTI program included hands-on activities that will foster the use of the team approach to solve problems, the development of communications skills, and utilization of technology, skills required into today's workforce. Field trips to transportation-related industries, government facilities, and transportation providers exposed students to real-world applications of STEM and introduce them to a wide range of careers in transportation.

The curriculum included activities from TRAC, the Mississippi TRANsportation and Civil Engineering program, currently implemented in select seventh grade Career Discovery classes across the state. Developed by the American Association of State Highway and Transportation Officials (AASHTO), TRAC is a diverse set of on instructional modules related to actual transportation problems and issues. Students work in teams to solve simulations of real-life transportation challenges. The program modules are complex enough that each can be easily adapted for students of all ages. It was adapted for the MSTI to challenge students to work in small groups to solve problems related to designing MagLev vehicles, structures, and intermodal urban transportation networks.

The program also addressed an important component in developing a workforce that can maintain America's competitive edge in STEM fields: leadership training. A key initiative of Mississippi State University President Robert H. "Doc" Foglesong is the development of leadership in young people through the Appalachian Leadership Honors Program. Dr. Cade Smith, director of the program, led the project session focusing on development of leadership skills.

MSTI opened with an orientation session for students and parents that introduced project and MDOT and MSTI personnel, provide details of the program, and explain rules and regulations. The closing ceremony included recognition of sponsors, a recap of the program with a slide presentation, and recognition for students.

#### **PARTICIPANT RECRUITMENT AND SELECTION**

Rising 10<sup>th</sup> and 11<sup>th</sup> graders for school year 2006-2007 were recruited for the MSTI from all school districts in Mississippi. A project information letter, student application, and project brochures were mailed to all mathematics department heads, science department heads, guidance counselors and school administrators, requesting assistance in identifying qualified students interested in applying and participating in MSTI.

A total of 24 students were identified for participation from all submitted applications. The project directors and MSTI project staff graded the applications using a ranking system criteria including completion of application, GPA, essay, and teacher recommendations. MDOT and FHWA representatives were integrated into this process and were involved in making selecting participants. Once the students were selected, an orientation package outlining the program requirements, including legal documents, and detailing institute activities was developed and distributed to the invited students. This process resulted in 19 students, including 11 female participants, electing to participate in the inaugural MSTI experience.

#### **MSTI CURRICULUM**

The curriculum was designed to provide the participants with a broad range of experiences related to various aspects of the intermodal transportation industry. A combination of presentations, computer simulations, hands-on laboratory-based manipulative activities, and field trips not only introduced them to the scientific, mathematical, and technological aspects of transportation system design and management, it also exposed them to the engineering and societal aspects of the diverse area. The goal of this program was to immerse the students in a program that shows the personal rewards and societal benefits of developing and maintaining a viable transportation infrastructure, and what it takes to design and operate such a conductive network.

Presentation of program information was provided through two primary formats; on-campus instructional exercises and off-campus field trips. On-campus instruction routinely utilized a single day to introduce the science, mathematics, and engineering approaches related to a specific transportation-related topic related to the design, operation, or use of highways and roads, railways, airports and airways, public transit, waterways, and pipelines. This instruction was subsequently reinforced by presenting the students with a design problem and allowing them to develop a solution and test it. Off-campus activities primarily consisted of field trips to give the students a tactile sense of the transportation industry and the diversity of activities and opportunities that it provides in terms of supporting society and as a career. These experiences were reinforced by bringing components of the field trip into the classroom instructional materials.

Of the fifteen weekdays that were part of the program, the last day was reserved for project displays, visiting families, and a concluding awards luncheon. Five days were used to provide opportunities for students to participate in a variety of off campus, transportation-related field trips. This left nine days for on campus instructional and experimental activities. Some on campus instruction did not involve laboratory activities; though the majority did.

### **On Campus Activities**

The goal of the instructional design was to expose student participants to a variety of transportation-related topics. To increase instructional effectiveness, we combined formal classroom-style instruction with manipulative exercises of a design nature for reinforcement. To motivate student attention and participation, the design problems were presented in a manner that allowed solutions to be evaluated and ranked. This instilled a sense of competition.

The on-campus program had a secondary goal of helping the students develop team skills. Issues of team development and operation were presented to the students along with team building exercises. This began at orientation and was reinforced by the activities in the program. For the design problem competitions associated with the lectures, groups of two to four students were constituted each day with each day's groups intentionally different than those of other days.

The competitions were devised to foster a sense of daily excitement and to help keep the students' attention throughout the program. Specifically, the projects and presentations that the students gave at the conclusion of each on-campus day were judged by their peers and the staff. Each student earned points based on the performance of their team in completing the assignment and the effectiveness of their solution presentation. By changing a student's assigned team, exceptional students did not outpace good students as this could have an adverse affect on student morale and program effectiveness.

In this way, groups competed to devise the best design on a daily basis while promoting a sense of individual competition; thereby rewarding those individual who remained focused throughout the MSTI experience. Furthermore, this kept students from having to rely solely on their personal skills; facilitating subject interest in those students who were not as academically prepared as other participants. To the contrary, teams were designed in an effort to keep the skill levels of each team comparable and the result of the competition in question until the last day of the Institute.

A generalized format for the daily schedule of activities was as follows. Start and ending times were selected so that participants did not have to compete with other students or campus traffic at time when either can be intimidating to younger people:

Time of Day	Activity
08:15 – 08:30	Review of previous day's activities, orient the students for the activities scheduled for the day ahead, and proceed to the instructional area relevant for the day's activities
08:30 – 10:15	Theme introduction, overview of the topic's significance to transportation, presentation of the mathematical tools
10:15 – 10:30	Break, organize competition teams, and introduce the team competition (experimental design) project
10:30 – 12:15	Present tools, materials, and approaches needed to undertake and resolve the experimental design problem
12:15 – 1:15	Lunch Break
1:15 – 3:30	Team problem solving exercise
3:30 – 3:45	Break and preparation for presentation of team solutions
3:45 – 4:45	Presentation of team solutions, evaluation, and scoring

The MSTI staff used a combination of TRAC® Modules, engineering design tools, and laboratory exercises supported by lectures and multimedia presentations to give the students desired exposure to a myriad of transportation-related topics. Each culminated in a team-orient project activity of an experimental nature.

TRAC, the Mississippi TRAnspOrtation and Civil Engineering program, was established in 1997. MDOT, in collaboration with the State Department of Education, is working to provide TRAC to seventh grade public Career Discovery students. However, TRAC is diverse enough that students of all ages may benefit from the program. Some of the activities involve working in teams with other students to solve simulations of real-life transportation challenges. It was adapted for the MSTI in this latter manner, as appropriate, in the following daily activities:

**Structural Systems** – Utilizing West Point Bridge Builder® software, students were exposed to the topics of stress, strain and moment in relation to the development of structures. They constructed small structures and test them, until they fail. The competition centered on getting the best design for a bridge per the West Point Bridge Program. This is a minimum cost problem.

**System Illustration** – Applying ModelSmart CAD or Bentley MicroStation®, students were introduced to graphical presentation of engineering systems. This project had them take measurements of an engineered system and develop a set of two-dimensional drawings to represent the three-dimensional system. The competition had the students do a layout of a

railway with respect to grade and turn restrictions and the design will be judged on the amount of “track” their design requires adjusted for failure to meet the design criteria.

**Transportation System Layout** – The students were provided with a brief course on surveying for highway planning, design and construction. This involved an introduction to the equipment uses, both land based and remote imagery, for the collection of survey data for proposed roadway sites. They were presented with some trigonometry and geometry pertaining to roadway alignment and staking. The competition project was to load data into the CAD software and use it to accurately depict a plot layout.

In a separate experience, students were presented with an overview of the Global Positioning System (GPS) and how it is being used to manage transportation systems. The students experienced the process of using remotely-sensed data for identifying land use and the issues of developing a transportation corridor. They were instructed on using hand-held GPS units to find locations. Using this latter skill, the students worked in teams as part of a GeoCache activity where they had to accurately locate and record the position of four hidden film canisters.

**Hydraulic Engineering** – Examining the forces of water and the impact it can have on transportation systems, students were introduced to the forces of drag and buoyancy. They studied energy dissipation in manmade structures. The competition project was to design a container to carry a defined load with the lowest drag when fully loaded without being submerged.

**Environmental and Water Resources Engineering** – Participants were presented with issues related to sediment and erosion control, retention basins and storm routing, wetlands delineation and mitigation, and design of flood control systems. The experimental component of this day’s activities concentrated on the design of a system that allows water to flow over an area at a high rate while minimizing the amount of erosion.

**Pavement Materials Design** – Students were presented with engineering information about the materials that can be used to construct transportation systems. The design of the materials for road systems was emphasized with some testing of materials for basic properties. The competition component involved the design and construction of a bench-scale road pavement system that was subsequently tested for rutting resistance in the Asphalt Pavement Analyzer (APA) over a 24-hour cycle.

**Building Materials Design** – While concrete is used for many roadways, it also has significant application in a variety of building systems; transportation related and not. A summary of what it takes to convert cement into concrete and the subsequent properties was reviewed. A project involving the design of a concrete with maximum strength and minimum weight was the project-oriented competition for this topic.

**Traffic Management** – The topics highlighted during this presentation included traffic flow and safety (e.g., reaction time, braking distance, sight distances, impulse and momentum), roadway planning, cost estimating, geometric design, and basic computer programming. Computer programming for design of signal timing and operation and flow calculations using TSIS® 6.0 was presented. The design problem was to design a traffic management system for a defined intersection to provide the maximum, safe traffic flow.

**Miscellaneous Topics** – A variety of short topics were presented in the time remaining. These involved the students doing internet-based research and the development of a power point presentation for a competition component, involved visiting representatives from MSTI sponsors making short presentations. Topics that were covered during these sixty to 75

minute presentations could include: Safety statistics for Mississippi and why we have the worst safety record in the US, innovative and alternative transportation systems (e.g., magnetic levitation, fuel efficient vehicles, mass transit, HOV, telecommuting), urban planning, interfacing intermodal systems, and future transportation needs.

### **Off Campus Activities**

Field trips were conducted with consideration given to weather when possible. Examples of the types of transportation-related activities that were observed during a field trip included the demolition and forming of concrete pavement sections, laboratory processes to design asphalt binders, operations at an airport, and operation of a lock and dam system. These students traveled down the Mississippi River on a barge provided by the Corps of Engineers. They experienced a lockage operation while on a twenty-foot research boat belonging to CEE. They observed an airport firefighting vehicle in operation. Industrial visits were also incorporated to observe activities at Nissan, Vicksburg District Corps of Engineers, and MDOT facilities. These were augmented with visits to MSU research centers which have transportation-related activities; e.g., Center for Advanced Vehicular Systems (CAVS), GeoResources Institute (GRI).

### **Leadership Component**

Currently, because of the many challenges that confront Mississippi, our citizens fail to see the opportunities of shared community investments yielding shared community growth. Although the timeframe for overcoming these challenges is long, the formula for success is simple: enhancing the leadership skills of our emerging adults likely to remain in Mississippi will result in shared community investment, which will yield shared social and economic growth. This formula begins at the individual level; however, individuals who have been transformed will reinvest their success in other citizens. These reinvestments ultimately yield community wide progress. The Sonny Montgomery Chapter of the Appalachian Leadership Honors Program conducted a three-hour program that focused on the role of leadership in economic emergence, which included industry recruitment and infrastructure development. The program also included a case study for students that centers around leadership and the previously mentioned economic development topics.

### **SPONSORS**

There were a number of organizations that were approached by Mississippi State University and MDOT about supporting the Mississippi Summer Transportation Institute. Many provided monetary support while others facilitated tours. The cooperation of federal, state, and corporate sponsors was integral to the activities. Opportunities for fieldtrips were identified through contacts with a number of groups. Other opportunities were developed by working with the Columbus Air Force Base (CAFB) base commander, the Golden Triangle Regional Airport, and USACE Tennessee-Tombigbee Waterway, Ergon, Paragon Laboratories, and Intergraph.

The organizations listed below have been identified because of their longstanding relationship with the Department of Civil and Environmental Engineering, the Bagley College of Engineering, and the Mississippi Department of Transportation. They have a demonstrated interest in supporting education, promoting interest in the transportation industry, and fostering a better understanding of the engineering profession. A personal solicitation was made to garner in-kind and financial support for the MSTI project. Those providing some level of support, in addition to those listed previously, include: Mississippi Asphalt Paving Association, Mississippi Concrete Industries Association, and the Mississippi Road Builders Association.

### **QUALIFICATIONS AND KEY STAFF**

The Center for Science, Mathematics and Technology (CSMT) and the Bagley College of Engineering have extensive experience in delivering programs in STEM for K-12 students and teachers. With funding from the National Science Foundation, the Appalachian Regional Commission and the United States Golf Association, the CSMT has conducted summer programs, in partnership with Northrop Grumman, Nissan, Tennessee Valley Authority, and Red Hills Mine, that place teachers and students in industry to learn real world applications of academic content and become aware of career opportunities in STEM.

The Bagley College of Engineering has a position devoted to education and outreach and conducts a number of programs each year for young people. To promote careers in science, mathematics, engineering, and technology among the youth of today, the Bagley College of Engineering at Mississippi State University has designed an innovative outreach program offering special activities, workshops, and projects throughout the year for students, teachers, and counselors in grades K-12. These activities are designed to provide a continuum of programs for students at various stages of their educational development. To ensure the development of a highly skilled technical workforce for U.S. Industry, students are presented with hands-on experiences in the application of engineering, mathematics, science, and technology.

Both the CSMT and the Bagley College of Engineering have faculty and staff with the expertise and extensive experience in developing programs (including curricular materials), partnering with industry, managing the logistics of housing students, conducting field trips, transporting students, conducting STEM competitions, and planning comprehensive programs.

The Project Coordinator was a graduate student in engineering who has participated in previous summer camp activities for high-school age students. He was responsible for direct supervision of the counselors as well as be a resource person for the Project Director Team in the project planning and implementation.

## EVALUATION

The project team developed an evaluation plan that utilizes both formative and summative assessment of the project. Student's attitudes about the transportation industry in general, the role of STEM in transportation, awareness of careers in the transportation arena as well as their perception of the skills necessary for success in engineering were assessed through post tests to determine the effect of MSTI on the students' attitudes and knowledge in these areas. Each individual activity as well as the overall MSTI experience was assessed.

The purpose of the MSTI evaluation is to provide useful information to MDOT, FHWA, MSTI project management, and other interested stakeholders regarding project implementation and to explore opportunities for overall program improvement. As defined in the project overview, ongoing evaluation strategies conducted by evaluation staff include assessing evidence of the project meeting the following objectives:

- Expose students to transportation and STEM roles in the transportation industry,
- Provide career awareness in the field of transportation and the civil engineering profession
- Provide opportunities for students to develop leadership skills and improve their work ethic.

To provide a comprehensive framework for the triangulation of evidence, and to increase the validity, reliability, and generalizability of findings, a mixed-method approach utilizing quantitative and qualitative data was employed throughout the evaluation process. Methods and data sources to be used over the course of the project include the following:

- Surveys: Surveys were used to assess the effectiveness and impact of the summer institution. All student participants were surveyed upon completion of MSTI. Surveys gathered information regarding program components including, but not limited to pre- and post-program attitudes toward STEM and the transportation industry, recruitment efforts, changes in career awareness, role of STEM in transportation, importance of developing

leadership skills, strengths/weaknesses of the project, and recommendations for project improvement. Additionally, student participants were asked to evaluate faculty presenters, sponsor presenters, field trips, facilities, and meals.

- Observations: Observations of project activities (e.g. presentations, activities, field trips, etc.) were used in assessing program effectiveness and impacts.
- Interviews: Structured interviews were scheduled and conducted with MSTI project staff. These interviews provided greater depth and understanding of the success of the overall project including, but not limited to general project implementation processes, student recruitment efforts, strengths/weaknesses of the project, and recommendations for project improvements.

## RESULTS

### General Interest and Knowledge

Surveys indicate there was an increase in interest across all subject areas after their participating in the MSTI. These numbers indicate a positive effect on student general interest in transportation, engineering, mathematics, and science.

The data gathered supports a significant increase in general knowledge across all categories after participating in MSTI. According to the data collected the most significant increases in students' understanding were found in the areas of careers available in the transportation industry and their overall knowledge of the civil engineering profession. Only 31% of participating students reported being *knowledgeable* of careers in transportation and none of the students reported being *very knowledgeable* prior to their participation in MSTI. After their participation, 53% reported being *knowledgeable* of careers in transportation and 37% reported being *very knowledgeable*. Although no student reported being *very knowledgeable* of the civil engineering profession before their participation in MSTI, 53% of the participating students reported being *very knowledgeable* of the civil engineering profession after participating in the summer institute.

### Benefit of MSTI Components

Participating students were also asked to rate the overall benefit of each component of the MSTI. An overwhelming 84% of student respondents indicated the Columbus Lock & Dam component was *very beneficial*. Closely following was the Nissan Tour component with 79% of the respondents reporting it to be *very beneficial*. The Columbus Air Force Base Visit and the Leadership Training components both received *very beneficial* ratings from 74% of student respondents.

### Influence of MSTI

Students were asked to comment on how they anticipate their experience with MSTI would influence the choices they make during the next school year. Answers varied, but all responses were positive. Some students reported their experience will influence them to work harder and make better choices. Other students were more specific saying, "It will help me in the college selection process..." and "I will take physics and challenge myself to do better on the ACT." Still others reported taking school more seriously and choosing their classes more wisely.

Participating students were then asked how their experience in MSTI will influence their choices regarding their education beyond high school. Students responded they now know they will need to work hard and study. Many of the responses specifically mentioned a desire to return to MSU for college, while other reported their decisions to pursue a degree in engineering.

When asked how MSTI will influence their career choices, some responses were very vague, while others specifically noted overall desires to become engineers. The more specific comments included, "I will most likely be an engineer and MSTI has helped with that choice." "This camp has enforced my interests in engineering..." "This camp definitely made me want to be an engineer."

### Student Experiences



When participating students were asked to identify the more interesting parts of the MSTI, they identified the tours and interactive, hands-on activities. Specific components mentioned were the Water Transportation Session, Nissan Tour, MDOT Visit, TRACS Activities, Concrete Materials Session, Riverboat Tour, Columbus Lock & Dam, and Leadership Training. Of all the comments, the most common response was the field trips. Some of the comments included, "I loved the field trips. Especially the riverboat tours and going to Jackson.", "The trips were more interactive than the classes", "Going on the trips (was) interesting to me...because I am a hands-on person..." and "The trips because we got to travel and have fun..." Other comments included, "I like being taught by several...professors." and "There was never a dull moment...Everything we did was interesting."

### **Student Impact**

Students participating in MSTI may have already developed an interest and high skill set in STEM fields prior to their MSTI experience. This previous interest may have had some affect on the way participants responded to questions regarding student impact.

In order to assess the overall impact MSTI had on the students' interest and confidence level in science and mathematics, students were asked to what extend the MSTI affected each of them. Overall, students reported that MSTI had an effect on their ability to understand new information presented to them in science and math classes. More than 40% stated that MSTI increased their confidence to participate in science and math classes.

### **CONCLUSION**

Overall, MSTI met its objectives. Students were able to understand the basic STEM concepts related to transportation and civil engineering, while developing leadership and interpersonal skills. Survey and anecdotal data confirm that the participants left the program with a significantly improved understanding of the academic requirements of the engineering profession and the diversity of career opportunities available in the transportation industry and related fields. All of the students said MSTI had affected them in not only an academic way, but also a personal way.

We plan on continuing MSTI for years to come. We anticipate the number of students involved will increase and this will present us with new challenges. However, there are several lessons learned by the staff which will apply. We found that:

- The effectiveness of exposing students to STEM concepts and technically-oriented problems is enhanced as the degree of personal contact increases. While computer programs can be sufficient to illustrate problems and their solutions, a tactile experience with real materials provides invaluable insights and vests the students more deeply in the learning process;
- The competitive environment used in the inaugural year of MSTI paid dividends as it engaged many of the students in ways that helped maintain interest through the last day of the experience. However, feedback during the program is needed to keep the interest elevated in more of the students; and
- Provide opportunities for the students to bond with each other, and with program staff, is essential in the development of leadership skills and improvement in work ethic. This bonding develops a greater sense of accountability and personal responsibility.

### **Dr. Donna S. Reese**

Dr. Donna S. Reese, associate dean for the college of engineering, has extensive experience with interacting with students. She participates in the college's summer camp activities. She served as undergraduate coordinator for the Computer Science & Engineering Department prior to moving to the dean's office. In this capacity, she was recognized by the university, as well as the National

Academic Advising Association for outstanding advising. She is also a John Grisham Master Teacher. She teaches introduction to engineering for freshman pre-engineering students.

**Emma E. Seiler**

Ms. Emma Seiler is the K-12 Educational Outreach Coordinator for the Bagley College of Engineering at Mississippi State University. She holds a B.S. in Biological Engineering and a M.S. in Civil Engineering from Mississippi State University. As Educational Outreach Coordinator, she is also responsible for coordinating summer programs such as WISE Women, University Familiarization Program for Minorities in Engineering, Women in Action, Mississippi Summer Transportation Institute, and Summer Engineering Experience. In addition, she has developed an engineering design project for girls called "The Cinderella Project." This project uses the engineering design process to design a sturdy, comfortable, yet fashionable shoe.

**Dr. Dennis D. Truax**

Dr. Dennis D. Truax, James T. White Chair, Head, and Professor of Civil and Environmental Engineering, has been a member of the MSU faculty for 26 years during which time he has worked as faculty advisor for the national award winning ASCE student chapter. In connection with the chapter, and his personal connections with administrators and teachers in the Starkville School District, he has developed numerous educational modules, made several presentations, judged many science fairs, and added to the writing of several education proposals. He is a Robert M. Scholtes Teaching Award recipient, an ASCE Fellow, and was recognized by Golden Key for his collegiate instruction and service.