AC 2010-1638: POSTER: ENGAGING TRANSPORTATION ENGINEERING ACTIVITIES FOR MIDDLE SCHOOL AND HIGH SCHOOL STUDENTS

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Engaging Transportation Engineering Activities for Middle School and High School Students

Abstract

In summer 2009, the Georgia Institute of Technology hosted the Technology, Engineering and Computing (TEC) Camp for rising seventh and eighth grade girls. The purpose of the camp is to expose middle school students to a wide range of engineering disciplines early in their educations in order to inspire campers to consider college majors and careers in these important fields. Three distinct activities were created to introduce the young women to the field of Transportation Engineering.

The purpose of the first activity was to help students recognize tradeoffs that individuals make when determining which mode of transportation to take for a long trip. Each student was asked to act as a travel agent and determine which mode (plane, car, bus, or train) a family of four would take from Atlanta, Georgia to Orlando, FL. Costs, greenhouse gas emissions, travel time durations, and trip schedules were provided for each mode. Students completed calculations to quantify tradeoffs and engaged in a group discussion to help capture personal preferences that were not captured in calculations.

The purpose of the second activity was to expose the students to problems that plague transportation engineers. Graduate students from Georgia Tech facilitated the discussion by posing questions, giving campers an opportunity to ponder the questions themselves, and then asking for suggestions in a discussion forum. The questions posed encouraged students to think about how to mitigate noise pollution, implement traffic calming measures in neighborhoods, improve safety for pedestrians, encourage carpooling, etc.

The purpose of the third activity was to illustrate the different considerations of a transportation planner. A large map of a transportation network, which included roads, a trolley line, a bus line, and a train line, was utilized in the activity. A home, daycare facility, school, and two workplaces were placed on the map. Students were instructed to consider a family of four, where each family member had to get from home to one of the locations on the map using the one automobile available, as well as the public transportation options. Students worked in small groups to figure out how to logistically get each individual to their destination. Through this exercise they recognized the importance of individuals having access to public transit.

These activities were more recently shared with 30 Atlanta area high school math teachers during a Center of Education Integrating Science, Mathematics, and Computing (CEISMC) program. They were also used to introduce a classroom of high school seniors, who are part of an engineering magnet program at a local high school, to transportation engineering.

Introduction

In summer 2009, the Georgia Institute of Technology hosted the Technology, Engineering and Computing (TEC) Camp for rising seventh and eighth grade girls. The weeklong TEC camp is designed to expose campers to a wide range of engineering disciplines early in their educations
in order to inspire campers to consider college majors and careers in these important fields. The camp is highly interactive with hands-on projects in areas such as webpage design, robotics, structural design, and transportation engineering. Campers are given the opportunity to explore engineering through interactive courses, seminars and laboratories that are lead by Georgia Tech professors and graduate students. Campers are encouraged to interact directly with the graduate students and to ask questions about life as a college student in engineering.

Transportation Engineering Activities

At the beginning of the transportation engineering session, a 10 minute Power Point presentation was presented to the TEC campers in order to provide a brief overview of the field of transportation. Then, three distinct activities were used to introduce the young women to Transportation Engineering. The group of 30 campers was divided into three groups and assigned to one of the three activities. The campers then had 20 minutes at each activity station before rotating to the next activity. At each activity station, one or two Georgia Tech graduate students lead the activity using visual aids posted on large tri-fold presentation boards, as well as additional handouts which are included in the appendices.

The first activity asked students to think about tradeoffs of different modes of transportation, such as cost, travel time, and emissions, by having students act as travel agents that are planning a trip. In the second activity, graduate students lead a discussion of problems that plague transportation engineers, such as congestion, crashes at intersections, and speeding. Campers were encouraged to think of multiple solutions to each problem. In the third activity, students had to figure out the logistics of how a family of four, all of which had to go to different destinations on a map, would get to their destinations using only one car. Campers were encouraged to think about multiple modes of travel.

In the sections that follow, detailed descriptions of each activity are provided, along with extra materials that can be used as handouts for each activity. This is followed by a brief description of the environments that the activities have been used in, as well as lessons learned.

Activity 1: Tradeoffs between Different Modes of Transportation

The goal of this activity was to help the students understand tradeoffs between four different modes of transportation (car, train, airplane, and bus) for a long trip. Students were charged with the task of comparing the cost, duration of travel, and pollution produced by each mode for a trip from Atlanta to Orlando for a family of four. To facilitate the comparisons, students were given handouts with supplementary information that included schedules (including departure times, arrival times, and trip durations) and fares per person for each mode of travel. They were also given the distance of travel that each mode covers and the estimated emissions per mile for each mode. The students then had to fill in the worksheet (found in Appendix 1) using the packet of supplementary information and a calculator. While the students were filling in the worksheets, the two activity facilitators walked around among the students, providing help as needed.

After doing the calculations and comparing the modes by cost, trip duration, and level of emissions, each student had to select which mode they would use to send the family of four from
Atlanta to Orlando. The students’ decisions were then discussed as a group with the Georgia Tech graduate students leading the discussion. In the group discussion, the graduate students emphasized other factors that may need to be considered, such as additional costs, comfort, convenience, and other personal preferences. For example, students often picked the airplane mode. However, they did not originally consider the cost of getting to the airport. In this instance, they could choose between driving, taking a taxi, or taking the Metropolitan Atlanta Rapid Transit Authority (MARTA) rail transit line. Then they further considered the cost of parking at the airport. Another factor that could be considered is the convenience of bypassing traffic in an airplane or on the train. This discussion enabled students to recognize that decision making encompasses a wide range of factors. Below, in Figure 1, there are two images of the activity being conducted.

![Figure 1. Pictures of Activity 1 during the TEC Girl’s Camp](image)

To complete this activity in your classroom, you can provide students with the fares found from local transit authorities from your nearest city to a popular vacation destination. For older students with access to computers, they can search for the fare information themselves. However, it is probably helpful if they cite the sources they found the fare information on. After students complete the chart and decide what mode they would use to send the family on their vacation, use a group discussion to emphasize that decision making encompasses more than just the numbers found. Specifically highlight the fact that comfort, convenience, personal preferences, and schedule, as well as many other factors, also play vital roles when individuals make decisions about transportation.

**Activity 2: Discussion of Problems Transportation Engineers Face**

The purpose of this activity was to give the students an opportunity to learn about a wide array of problems transportation engineers tackle. Nine different questions were provided on the tri-fold presentation board, and on the worksheets, which can be found in Appendix 2. The topics included increasing transit ridership, increasing pedestrian and bicyclists’ safety, determining correct signage, decreasing congestion, increasing air quality, and implementing traffic calming. Each problem scenario was posed to the campers by the graduate student facilitator who gave specific details about the problem. Students were then asked, as a group, to offer possible solutions to each problem. If students had trouble figuring out a solution, a graduate student offered up a possible solution.
An important aspect of this exercise was that no question had one correct answer. Every question had multiple answers that were correct, creating interest and excitement among the students. This aspect of the activity helped to get all of the students involved in the discussion. Below, in Figure 2, there are two images of the activity being conducted.

Figure 2. Pictures of Activity 2 during the TEC Girl’s Camp

To complete this activity in your classroom, first ask students to fill out the worksheet (provided in Appendix 2) on their own. Then divide the class into small groups, and let the groups work together to determine possible solutions to the nine problems. Finally, have a class discussion to determine good solutions for each problem. It may be helpful to research the questions before administering this lesson.

Activity 3: Logistics of Moving a Family of Four to School and Work with Only One Car

The purpose of this activity was to illustrate the many different considerations of a transportation planner and demonstrate how public transportation is used by individuals. This activity also demonstrates that access to public transit is important for families without an automobile or without multiple automobiles. A large map that included roads, a trolley line, a bus line, and a train line was constructed using photos of each destination in combination with craft yarn that was color-coded by mode type. Photos of a home, daycare facility, school, and two workplaces were placed on the map of the transportation network.

Campers were instructed to consider a family of four, with two parents who work full-time and two children (one child is school-age and the other is still too young for school). The graduate student facilitators explained to campers that each weekday morning, both parents have to get to their workplaces, as well as dropping off one child at daycare and the other child at school. In this scenario, the family only has one automobile. Campers were then asked to use the map of the transportation network to determine how the parents could get everyone to their destinations most efficiently. Campers first worked individually to fill out the worksheet (provided in Appendix 3) and then in small groups. In this exercise, students learned the importance of public transit in a fun and interactive way. Below, in Figure 3, there are two images of the activity being conducted.
To complete this activity in your classroom, first create a large map for students to use. It is helpful if you color code the streets, the transit rail line, the bus line, and a trolley line. Then place a home, two work destinations, a school, and a day care on the map. It would be helpful to students if you mimic the city you live closest to so that students can relate the map to possible experiences they have had. Let students brainstorm how they would get each parent and the two children to their respective destinations using the different modes available. Finally, have a group discussion, allowing students to show the classroom how they completed the exercise.

Dissemination

These activities were designed with the intention to use them across a wide range of audiences. So far, they have successfully been used in the Technology, Engineering and Computing Camp and to introduce a classroom of high school seniors at Westlake High School to transportation engineering. These activities were also shared with 30 Atlanta area high school math teachers during a Center of Education Integrating Science, Mathematics, and Computing (CEISMC) program.

Technology, Engineering and Computing Girl’s Camp

The Technology, Engineering and Computing (TEC) Camp was a weeklong camp for rising seventh and eighth grade girls hosted by the Georgia Institute of Technology. One of the sessions offered was a session introducing the students to Transportation Engineering. During this session, six graduate students facilitated the three abovementioned activities. Several important lessons were learned during the first implementation of the activities. First off, when using them in rotation it was determined that Activity 3 was shorter than the other two activities. Thus, to compensate, that lesson was expanded on by letting students make an original plan for how everyone gets to their destinations and then posing questions that made some change their original plan. For example, students were questioned on whether or not the direction they had their car traveling would be affected by rush hour traffic. By posing this and similar questions, students got to explore more factors that go into logistics decisions. Another important lesson was learned during Activity 1. Students seemed to elect modes of transportation they were comfortable using or had experience with. To foster further learning, the facilitators let students engage in discussion with one another on the pros and cons of taking a plane, riding the bus,
riding the train, and driving to a vacation destination. This experience was unique because it allowed students to teach students from their own experiences. It also helped students form more open-minded opinions about modes of transportation that they had not experienced.

**Introduction to Transportation Engineering at Westlake High School**

Westlake High School in Atlanta, GA has a Math and Science Magnet Program that prepares students for the academic and career fields of math, science, engineering, and technology. For the engineering track of the magnet program, senior students take an introduction to engineering class which surveys different types of engineering. To introduce students to transportation engineering, two graduate students from Georgia Tech gave a lecture about transportation engineering and then helped students complete Activities 2 and 3 (explained in detail above). The activities provided a foundation for a three week unit on transportation engineering. This group of students was a little older, so naturally they provided more intricate answers to the problems posed in Activity 2. However, interestingly enough, many students had not experienced riding on public transit, even though they live close to many public transportation options. Thus, for Activity 3, background had to be provided on the differences between a trolley line and a metro rail line. In the future it is essential that basic background is provided on the various modes of public transportation. Pictures of the different public transit vehicles would also be helpful. Another lesson learned from this activity was that more students were outspoken in this advanced class. Thus, using smaller groups would have enabled more students to share their ideas.

**Center of Education Integrating Science, Mathematics, and Computing (CEISMC) Program**

The three activities were shared with 30 Atlanta area high school math teachers during a Center of Education Integrating Science, Mathematics, and Computing (CEISMC) program. The teachers were very enthusiastic about teaching students the important economic concept of transportation tradeoffs through the use of real life scenarios. At the program’s completion, several of the teachers eagerly asked for copies of the handouts to use in their own classrooms.

**Conclusion**

Three distinct activities, designed to use across a wide range of audiences, can be used to provide middle school and high school students with an introduction to the field of Transportation Engineering. The activities are highly interactive and utilize group discussions to get students thinking about transportation issues. The activities have already been used in three separate programs, with feedback and lessons learned provided after each time the activities were used. These activities can be easily modified and adapted in order to be appropriately utilized in classrooms of any city or grade-level.

**Acknowledgements**

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Appendix 1 – Activity 1 Worksheet

Exploring the Tradeoffs between Different Modes of Transportation

In this scenario, you are a travel agent planning a vacation to Orlando for a family of four. You have to figure out whether they drive, take the bus, take the train, or fly from Atlanta to Orlando. You should consider the time each mode takes, the cost of each mode, and the environmental impact of each mode. If you decide the family should fly, also consider how they will get to the airport (by car, MARTA, or taxi) and how much the trip to and from the airport will cost.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Time</th>
<th>Emissions</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 Ford Explorer (4door)</td>
<td>6 hours 47 minutes</td>
<td>1.21 lbs CO2 * 880 miles = 1,064.8 lbs CO2</td>
<td>$2.89 * (880 miles / 18 mpg) = $141.29</td>
</tr>
<tr>
<td>2006 Toyota Prius</td>
<td>6 hours 47 minutes</td>
<td>0.47 lbs CO2 * 880 miles = 413.6 lbs CO2</td>
<td>$2.89 * (880 miles / 45 mpg) = $56.52</td>
</tr>
<tr>
<td>Bus</td>
<td>9 hours 55 minutes</td>
<td>0.18 lbs CO2 * 880 miles * 4 people = 633.6 lbs CO2</td>
<td>$53 per ticket * 4 people = $212</td>
</tr>
<tr>
<td>Train (Amtrak)</td>
<td>33 hours (There is no direct route. The train goes to Washington D.C. first and then to Orlando)</td>
<td>640 miles from Atlanta to D.C. + 850 miles from D.C. to Orlando = 1,490 miles 0.46 lbs CO2 * 1490 miles * 4 people = 2,741.6 lbs CO2</td>
<td>$196 per adult ticket * 2 + $98 per child ticket * 2 = $588</td>
</tr>
<tr>
<td>Airplane</td>
<td>3 hours 45 minutes</td>
<td>0.64 lbs CO2 * 880 miles * 4 people = 2,252.8 lbs CO2</td>
<td>$270 per ticket * 4 people = $1,080</td>
</tr>
</tbody>
</table>

How should the family travel from Atlanta to Orlando?
The airplane is fastest but also the most expensive. The Prius is a good option because it is the cheapest and also has the least amount of emissions. However, a Prius may be rather small for a family of four with luggage. The Explorer may be a good option for a larger family. The train has no direct route, so it takes far too long. The bus is less expensive than the train or airplane and also has less emissions.

Are there any other factors that you could consider?
Comfort, safety, convenience, other personal preferences. Cost of getting to the airport.

Note that the following assumptions were used to make the calculations. Students would be expected to find this information from handouts provided by the teacher that give schedules, costs, and emissions.
Gas is $2.89 per gallon
440 miles from Atlanta, GA to Orlando, FL (880 roundtrip)
Prius gets 45 mpg on the highway, 0.47 lbs CO2 per mile
Explorer gets 18 mpg on the highway, 1.21 lbs CO2 per mile
Bus is 0.18 lbs CO2 per passenger per mile (assuming a long-haul tip on non-alternative fuel bus)
Amtrak is 0.46 lbs CO2 per passenger per mile
Airplane is 0.64 lbs CO2 per passenger per mile
Emissions were calculated from www.travelmatters.org (except for calculations for Bus) which is a website completed through a project sponsored by the Transit Cooperative Research Program of the Transportation Research Board of the National Academies.
Appendix 2 – Activity 2 Worksheet

Discussion of Problems Transportation Engineers Face

Suppose you are a traffic engineer for a particular city. How would you solve the following problems:

1. A lot of money has been spent to put in a large Metrorail line. How can you encourage individuals to use it instead of driving downtown?

2. On Buford Highway a lot of pedestrians have nearly been hit by cars while crossing the street. How can you make it safer for pedestrians?

3. Bicyclists don’t feel safe riding downtown on Peachtree Street. How can you make them feel safer?

4. Drivers keep running stop signs at the intersection of Calhoun and Center Streets. How could you make the stop sign more apparent to the driver?

5. There’s heavy congestion on the interstate and not enough room to add an additional lane. What else can you do to reduce congestion?

6. Atlanta has problems with air quality. How can individuals be encouraged to carpool?

7. A lot of cars drive too fast through a local residential neighborhood where a lot of children play in the streets. How can you slow traffic?

8. There are a lot of car crashes at the intersection of North Street and 10\textsuperscript{th} Street. What could you do to eliminate some of the car crashes?
Appendix 3 – Activity 3 Worksheet

Logistics of Moving a Family of Four to Work and School with Only One Car

In this scenario, there is a family with two parents who work full-time and two children (one child is school-age and the other is still too young for school). Each weekday morning, both parents have to get to their workplaces. Also, they have to drop off one child at daycare and the other child at school. The family only has one car. Using the map that shows the transportation network, how can the parents get everyone to their destinations?

Available Modes: Drive Automobile (Single Occupancy or Carpool), Bus, MARTA Train, Trolley

What factors can they use to make the decision?

What are their options?

Which mode(s) should the family use?

Mom:
Dad:
Child 1 to daycare:
Child 2 to school:

What route(s) should they follow (i.e. in what order should they make the trips)?