Intelligent Transportation Systems Institute
Center for Transportation Studies
University of Minnesota

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Traffic Control

Lessons for High School Students



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Traffic Control Lessons for High School Students - Synopsis

Lesson Structure

The Intelligent Transportation Systems (ITS) Institute Traffic Control Lessons for High School students is comprised of five lessons, each of 2 to 3 activities. Each activity is designed to take between 15 and 20 minutes. To accommodate varying teacher and class schedules, each lesson may be spread across several class periods. We suggest Lesson 5, "Traffic Data Analysis", be scheduled for a minimum of two class periods. The lessons get sequentially more complex and detailed, culminating in sophisticated data analysis.

We have also included an addendum that contains suggestions for extended projects featuring problems from the several disciplines that make up the transportation engineering field.

Suggested Sequence

Although there is a clear logical progression, the lessons may be taught individually or out-of-sequence. If there is a limited amount of time, we suggest that Lesson 1 be taught, followed by nearly any lesson or combination of subsequent lessons. The following pairings may be particularly coherent:

- Lessons 1 & 2
- Lessons 1 & 2 & 3
- Lessons 1 & 3 & 4
- Lessons 1 & 4
- Lessons 1 & 5

Synopsis

Lesson 1 – Intro to Signal Timing

Lesson 1 introduces the Traffic Control Simulation. Students explore the simulation by comparing the results of manual versus fixed-time traffic control. Students compare graphs generated by both manual and fixed-time simulations to conclude that fixed time signals control traffic more consistently and with lower queues and delays. The lesson concludes with students following the scientific method to experiment with how altering variables such as offset, traffic volume, traffic speed, and network size affects traffic timing.

Lesson 2 – Intro to Queuing Theory

Following a brief introduction to queuing theory and a discussion on why queues form, students apply the theory's concepts in an instructor-led simulation. Students graph the data generated by the simulation to determine when queues form, how long it takes queues to dissipate, and identification of the vehicles with the shortest and longest delays.

Lesson 3 – Intersection Analysis

The lesson begins with a discussion around why traffic queues are undesirable and the common characteristics shared by all queues. The instructor then demonstrates with graphs the concept of saturation flow, cycle and phase. Students experiment with different values in a spreadsheet containing D-D-1 properties to determine the best signal timing for a low traffic volume. These values are tested in the Traffic Control simulation and compared with results from other students.

Lesson 4 – Quantitative Experiments

Students design a quantitative experiment using the Traffic Control simulation to determine how altering one or more variables for signal timing and traffic speed impacts traffic flow. Students develop a quantitative hypothesis, then use measurements from the simulation (queue, delay, score, P.I.) and interpretations of relevant graphs to explore specific effects.

Lesson 5 – Traffic Data Analysis

Day 1 - After a brief description of the traffic control technology used in the metro area and throughout the state, students use the MN/DOT's DataPlot application to examine data from a detector station.

Day 2 - Students compare different variables and determine the relationships between the variables. The lesson concludes with students working in small groups to analyze data from a stretch of highway to identify the optimal time to close a lane for a 1-week project. A role-playing scenario is suggested as a culminating activity in which students present their results as "engineers" to a student panel "city council."

Correlations with the Minnesota Academic Standards

Through participating in this program, students will develop knowledge and skills that help them meet the following Minnesota benchmarks in science:

Grade 8 – History and Nature of Science – Scientific Inquiry

Benchmark 1. The student will specify variables to be changed, controlled and measured.

Benchmark 2. The student will use sufficient trials and adequate sample size to ensure reliable data.

Benchmark 3. The student will use appropriate technology and mathematics skills to access, gather, store, retrieve and organize data.

Grade 8 – History and Nature of Science – Historic Perspectives

Benchmark 2. The student will cite examples of how science and technology contributed to changes in … transportation, information processing or communication.

Grades 9-12 – History and Nature of Science – Scientific Enterprise

Benchmark 1. The student will compare and contrast the purposes and career opportunities of engineering, technology and science.

Benchmark 2. The student will provide an example of a need or problem identified by science and solved by engineering or technology.

General Equipment Requirements

- Students need access to Internet-connect computers loaded with the following software:
  - Word processor
  - Spreadsheet application
  - Sun's Java WebStart.
- School proxy servers must allow access to Java WebStart applications.
- Teachers need their own computer workstation complete with digital projector and the following software:
  - Word processor
  - Spreadsheet application
  - Sun's Java WebStart.

Lesson 1 Materials

For Students:

- Handout (found at the end of this lesson) containing:
  - directions for accessing the Traffic Control simulation, (http://street.umn.edu/GAME_traffic.html)
  - directions for taking screen captures,
  - template for conducting an experiment.
- Computer with Internet connection and Java enabled for each student or small groups of students.
  - NOTE: Students will need the ability to either save or print a word processing document.

For Teachers:

- Computer with projector, Internet connection and Java enabled for the teacher
- "1 x 1 Fixed Time Graph" (found at the end of this lesson and in the Powerpoint presentation included in the teacher materials).

Lesson 2 Materials

For the instructor:

- Stop watch
- Whiteboard

- Green and red white board markers

For students:

- Graph paper and pencils or a spreadsheet program and computer for each student

Lesson 3 Materials

For the instructor:

- Computer with projector

For the students:

- Computer with word processing and spreadsheet programs, capable of:
  - reading and working with .xls (Excel) files
  - saving or printing student work
- "Traffic Analysis.xls" spreadsheet loaded on individual computers.

Lesson 4 Materials

For the instructor:

- Computer with projector.

For the students:

- Computer with word processing program and the ability to save documents.
- Link to Traffic Control simulation: http://street.umn.edu/GAME_traffic.html

Lesson 5 Materials

For the instructor:

- MN/DOT's "All Detector Report, February 2008": http://www.dot.state.mn.us/tmc/trafficinfo/downloads/adr.pdf
- MN/DOT's Traffic Data Collection Map for either Greater Minnesota or the Metro Area: http://www.dot.state.mn.us/traffic/data/html/collsites.html

Outstate: http://www.dot.state.mn.us/traffic/data/maps/countsites/outstatesites.pdf
Metro: http://www.dot.state.mn.us/traffic/data/maps/countsites/metrosites.pdf

- computer with projector

For the student:

- computer with ability to print or save files, loaded with:
  - Sun's Java Runtime Environment.
  - word processing software
  - MN DOT's DataPlot software available free at [http://data.dot.state.mn.us/datatools/DataPlot.jnlp]

Lesson 1: Introduction To Signal Timing

Synopsis

Students work with the Traffic Control simulation to compare controlling traffic manually versus using the fixed-time controls. Students compare graphs generated by both manual and fixed time simulations to determine that fixed-time signals control traffic more consistently, with lower queues and delays. The lesson concludes with students experimenting with how altering variables such as offset, traffic volume, traffic speed, network size affects traffic timing.

Objectives:

- Students will follow the scientific method to conduct an experiment.
- Students will compare graphs generated by traffic patterns to determine whether a fixed or manually timed system is more consistent, efficient and reliable.
- Students will identify how variables such as vehicle speed or network size affect system performance.

Glossary:

The following terms are used throughout the lesson and demarked with **boldface**. For students with limited exposure to science and math, consider briefly reviewing these terms as they apply to traffic management before beginning the lesson.

- **efficiency –** a system's ability to reduce the amount of traffic delay.
- **offset -** the amount of time that a signal light changes slightly off from the rest of the system or a set difference of time from a central clock.
- **queue -** a closely spaced collection of vehicles

Activity 1 Materials

For Students:

- Handout (found at the end of this lesson) containing:
    - directions for accessing the Traffic Control simulation, http://street.umn.edu/GAME_traffic.html
    - directions for taking screen captures
    - template for conducting an experiment.
- Computer with Internet connection and Java enabled for each student or small groups of students.
    - NOTE: Students will need the ability to either save or print a word processing document.

For Teachers:

- Computer with projector, Internet connection and Java enabled for the teacher
    - "1 x 1 Fixed Time Graph" (found at the end of this lesson and in the Powerpoint presentation included in the teacher materials).

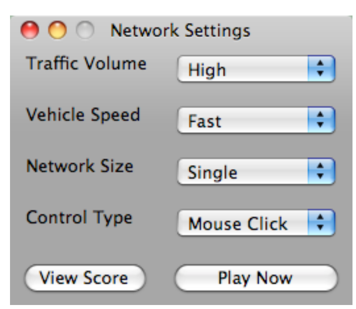
Activity 1 Preparations

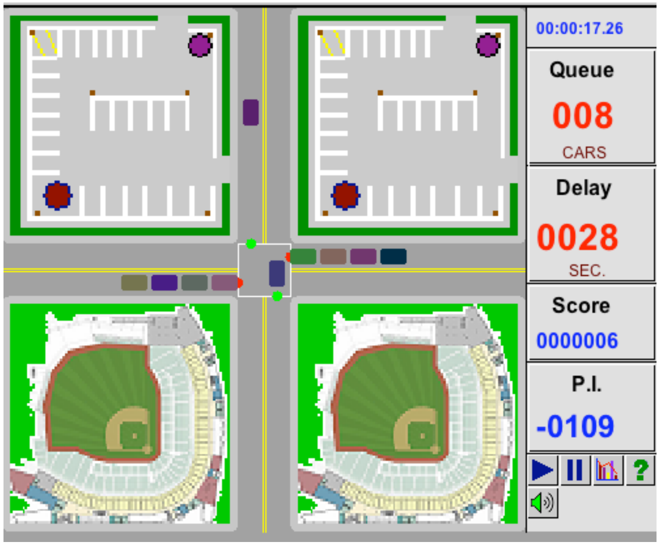
- Load the handout found at the end of this lesson onto student machines. You may wish to make hard copies of the handout as well.
- A few days prior to the lesson, test the Traffic Control simulation on each student machine. If the simulation does not run, contact your system administrator and request that proxy permissions are set appropriately for the application to work.
- Ensure that students have the permission to save and/or print documents from the machines they will be using.

Activity 1: Intro to Signal Timing

Students use the Traffic Control simulation to complete several experiments to determine how to create a consistent traffic pattern. To keep track of the experiment results, students will take screen captures of graphs and paste them into a word processing document. They will note the score, Performance Index, and ending queue length.

1. Explain that the objective of a traffic signal network is to manage traffic through a road system as efficiently and consistently as possible.
2. Direct students to the handout and point out how to access the simulation. Direct students to launch the simulation.
3. Give the students time to explore the simulation on their own. They should discover how to adjust the traffic flow settings, pause the simulation, and create graphs.
4. For students who are younger, less able, or more cautious, you may wish to provide additional guidance. In this case, demonstrate the four pull-down menus and how to use them to set the first simulation with the following settings:
    - **high** traffic volume
    - **fast** vehicle speed
    - **1 x 1** network size
    - **mouse click** control type

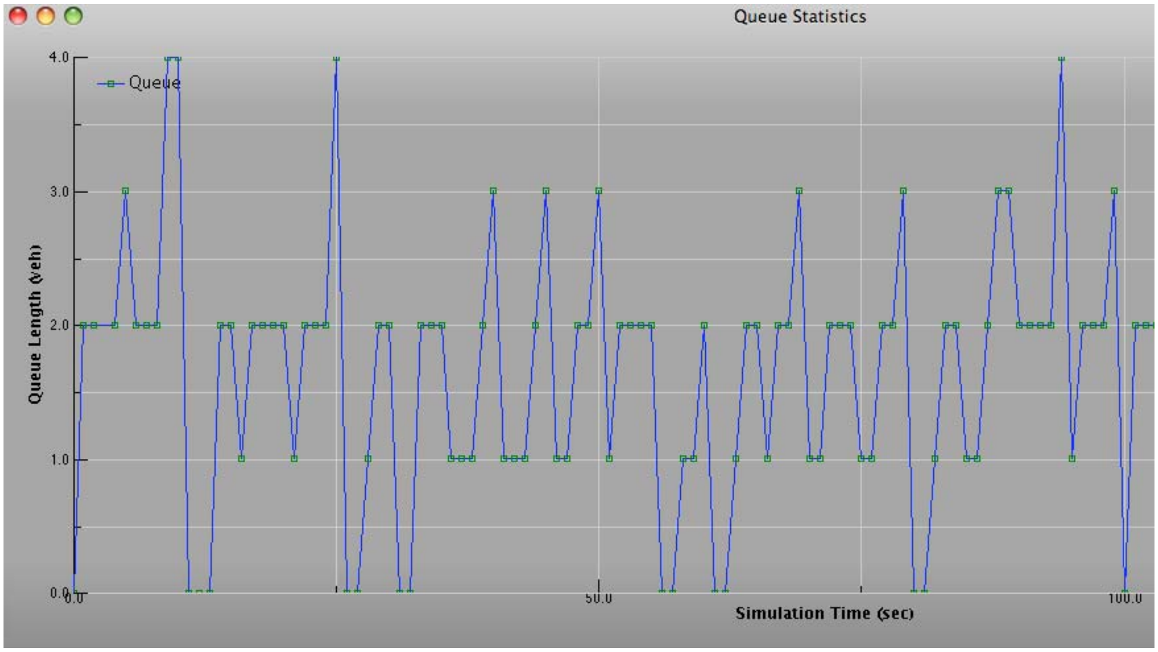




Additional teacher notes:

- You may wish to remind students that the simulation's objective is to keep the queue and delay at a minimum.
- The queue length is the number of vehicles waiting at a traffic signal. A long queue indicates inefficient signal timing.
- "P.I." means "performance index" – a combination of the queue and delay measures. A system that's performing without any delay or queue will have a PI of zero (0), which is the maximum possible value. In this simulation, the theoretical best P.I. is -0001.

5. The Lesson 1 handout provides additional instructions and is designed to allow student to progress at their own pace with minimal teacher direction. Depending on the group of students and the teacher's preference, the teacher may wish to have students stop at the end of Activity 1 or simply continue on to Activities 2 and 3.
6. When they are creating their word processing document with the graph's screen shot, remind students to type their simulation's score and ending queue length, then save the file in a place and with a name appropriate for the school's system.
7. For class discussion, display the "1 x 1, Fixed Time" graph available in the accompanying Powerpoint document. Discuss the pattern displayed in this graph. Does the graph depict a consistent traffic pattern?



"1 x 1 Fixed Time"

8. Ask students to compare their graph with "1x1 Fixed Time" graph. Do the graphs differ? Were they able to maintain as consistent a traffic pattern? Which graph depicts a more consistent traffic pattern? Which graph depicts a pattern with a consistently lower queue? If students used the manual control as directed, their graphs should be less consistent in both the height and spacing of the queue peaks.

Assessment: Written Reflection

1. Review points from discussion. If desired, have students to write short answer reflection on these questions.
   - How did changing the number of cars (students) affect how well the intersection was handling **traffic flow**?
   - What would eventually happen if even more cars started using the intersection?
   - How did changing the signal timing affect traffic?
   - What would result if signals performed inconsistently?
   - Why is a timed system is more efficient, consistent and reliable?
   - Prompt students to save the file.

Activity 2: Fixed Time vs. Manual Control

1. The Lesson 1 handout provides specific directions for the students. Teachers may wish to thoroughly blend Activities 1 and 2 depending on logistical considerations and student abilities. With more advanced groups, you may wish to skip Activity 2 and go straight from Activity 1 to Activity 3.
2. Remind students that the simulation's goal is to keep delay and queues to minimum, and that they should write the various scores from the simulation (queue, delay, P.I, score) in their word processing document with their graphs.
3. Some groups may need reminders about the scientific method, particularly regarding proper formulation of a hypothesis. Once any necessary background is provided, allow students to proceed with the activity at their own pace.
4. Ask students to generate a graph for the simulation just run and copy it into the same word processing document from Activity 1, as well as the PI and score. Remind them to save the file.
5. Model the scientific method as necessary and direct students to the handout where steps are outlined. Remind students that a hypothesis is nothing more than a thoughtful guess.
6. Discuss with students whether they think it's more efficient to manually operate traffic signals or to program them to operate in a system. Guide students to understand that given the same traffic volume and vehicle speed, a timed system will be more consistent than a manually timed system. This is because a manually-controlled system is inherently inconsistent. An engineered system will remain functionally consistent unless a part of the network fails or the variables for which it was designed change dramatically.
7. Direct students to write up a conclusion for the experiment. Was the hypothesis confirmed?

Activity 3: Variable Experiments

This final activity gives students the opportunity to further apply the scientific method to the Traffic Control simulation. The following experiments may be done with the class as a whole, assigned to smaller groups of students, or given as optional assignments for students to select. Students should continue to follow the scientific method:

- form a hypothesis,
- develop an experimental procedure,

- take notes on their observation and data (including screen captures, system scores, etc.)
- develop a conclusion based on their observation.

Experiment 1: Offsets

- Using the fixed time control and same traffic volume and speed as in the previous activity, demonstrate adjusting the offset for one or more intersections in a 2x2 network to attempt to increase system performance. After students have played a few simulations, discuss: What did “offset” do to the signals? What settings were the most effective for this type of network? Encourage students to refer to their graphs to bolster their argument.
- Have students meet in small groups to share findings and discuss what they consider the best settings and then test others settings in their own simulation.

Experiment 2: Increased Volume or Speed

- Propose changing a variable like traffic volume or speed. How does the change affect system outcomes (simulation score)?

Experiment 3: Increased Network Size

- Propose changing the network size. How does the change affect system outcomes (simulation score)?