# INITIATE Lesson Plan: Routes – Investigations for Designing Routes

***Lesson plan at a glance...***

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| Name | Routes – Investigations for Designing Routes |
| Course | Statistics |
| Grade level | 9th to 12th |
| Prerequisites | Speed, Distance and Time; Average and Standard Deviation. |
| Time | **Preparation:** 10 to 15 minutes<br>**Instruction:** 95 minutes |
| Standards | *Common Core:*<br>• ***S-IC:*** *Making Inferences and Justifying Conclusions - Make inferences and justify conclusions from experiments, observational studies and sample surveys.*<br>• ***S-ID:*** *Summarize, represent, and interpret data on a single count or measurement variable.* |

***In this lesson plan…***



## Lesson Overview

The smart car uses many statistical methods and data analysis tools to provide a safe and comfortable ride. Along with this, the smart car needs to perform efficiently. The smart cars today use GPS modules without which they would not be able to operate. In this lesson, an experiment is to be conducted to find the total time taken by the smart car when going from point A to B using two different routes, R1 and R2, by writing two different programs to traverse each route. Once they are done writing the programs, the students need to calculate the total time taken on each route. They will perform this experiment thrice and will find the average time taken in traversing each route. They also need to find the standard deviation. Based on the average time taken and the standard deviation, they infer which route should be taken to reach point B from A.

## Driving Questions

Overarching Driving Question:

- How will autonomous vehicles affect the differently abled people of our society?

Lesson Specific Question:

- What routes need to be planned for these smart buses in Toledo?
    - What are some of the functionalities that your autonomous paratransit bus should have?

## Materials and Equipment

- For the student:
    - *Required:*
        - A smart car kit (one (1) kit per x students recommended)
        - An Android tablet/chromebook connected to the smart car.
        - A cardboard with the map of the routes.
        - A stopwatch

## Preparation Tasks

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|---|---|---|
| | • Check whether all tablets are working, connected to the smart car, and have sufficient battery in them.<br>• The markings on the cardboard must be clearly visible.<br>• To check, whether the smart car is working, try to run the smart car using a single command to make the car move forward for 2 seconds. | 5 to 10 minutes |

## The Lesson

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| **Warm-up Activity: Information Gathering and Brainstorming** | 10 minutes |
| **Activity 1: Speed of GoPiGo** | 30 minutes |
| **Activity 2: Optimum Route** | 45 minutes |
| **Wrap-up: Conclusions and Inferences** | 10 minutes |

## Warm-up Activity: Information Gathering and Brainstorming (20 minutes)

**Activity Overview:** In this activity, the lesson is introduced, and useful information is provided about the activities that follow.

**Activity**:
Demonstrate on how can google maps find the route from Bowsher High School to Franklin Park Mall using the tablet.
OR
A short video on "How Google Maps find the best route for you" (https://www.youtube.com/watch?v=hxI1SmcDBpk) (Google Incorporation, 2016)

Google the techniques used by Google Maps to determine the best route. Answer the following questions:

1. Do these techniques involve Math in any way? If yes, then what topics do they think are involved in the computation? If not, then how do they do it?
2. What factors do you think are considered while calculating the quickest path?

**Conclusion:**
Google/Apple collected all the available road data, including speed limits, traffic lights, drawbridges, etc., and then use statistical analysis tools (formulas for calculating average, standard deviation, etc.) to find Estimated Time of Arrival (ETA).

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## Activity 1: Speed of GoPiGo (30 minutes)

**Problem Statement:** Find out the average speed of GoPiGo through experiments.

- Run the smart car for 2, 3, 4, 5, 6, 7, 8, 9, 10 seconds.
- Consider the Time and Distance covered and fill up a table as shown below.
- Find the Speed for each pair of values.
- Then take the average of all values of speed and find the average speed.

| Time (s) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Distance (inch) | | | | | | | | | |
| Speed (inch/s) | | | | | | | | | |

### Section 2: Gathering Data (45 minutes)

Students can be given separate cars. They will run the smart cars for the given times. For each run, they will measure the distance (by measuring tape) covered by the smart car. The Distance is then recorded into the table. The speed for each time is calculated using the following formula:

*Speed = Distance/Time.*

### Section 6: Analyzing the Solution (10 minutes)

An average of all the values of speed is the actual speed of the GoPiGo.

**Teaching Tips:**

- *Students will solve this in group.*
- *To plot the graphs students should use the graph paper.*
- Teacher will ask the students “What information can you derive from the graph you got?”. They should come up with the answers like:
  - Idea about the average
  - What is the deviation of actual values from the best fit line

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## Activity 1: Optimum Route (1.5 hours)

**Problem Statement:** Find the fastest route from Franklin Park Mall to Toledo Zoo, given there are two routes, R1 and R2. Start from Franklin Park Mall. The speed limit is given in percentages, while the distance on each road is given in inches.

1) Based on the Map (Figure 1) displayed to them they will have to devise an algorithm to traverse the route
2) Program the GoPiGo smart car.
3) Represent the data in the diagram in the form of separate tables for both the routes R1 and R2.
   The table must contain:
   - given information and constraints (speed limits and distance on each road),
   - time taken at stop sign is (3 seconds),
   - time taken at traffic light is (6 seconds),
   - Calculated information (total time taken).

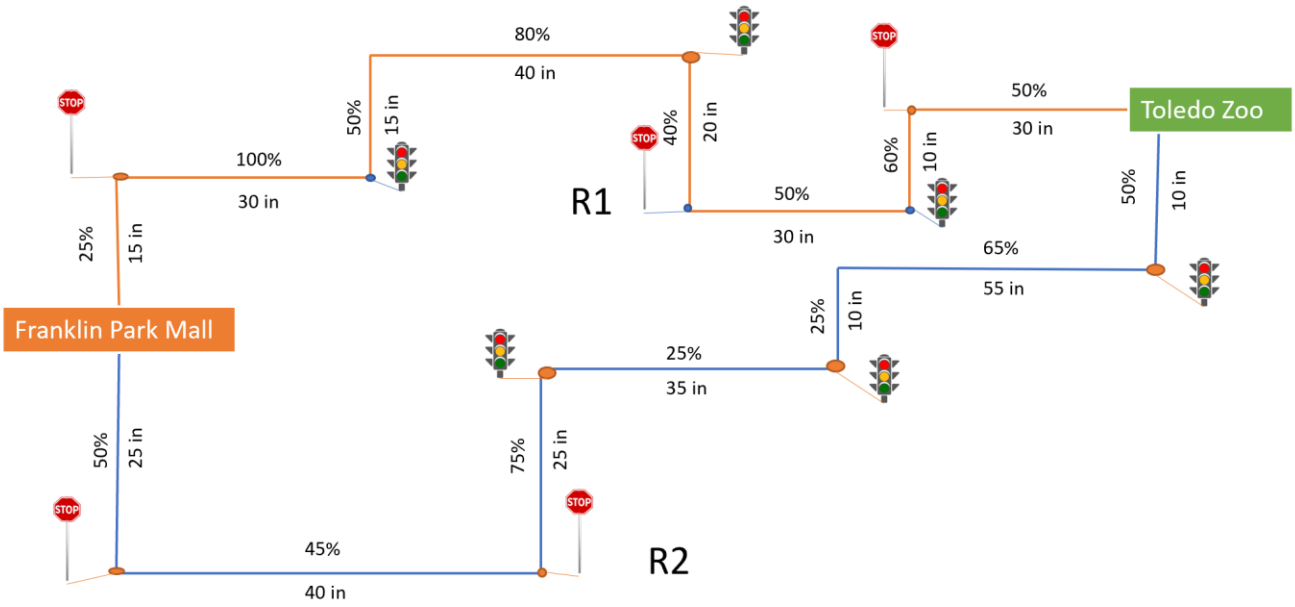


Figure 1

**Section 1: Devising an Algorithm** (15 minutes)

Divide the class into 2 groups. one group will traverse R1, while the other will traverse R2
Use the following information to devise the algorithm.

**There are three rules for devising this algorithm.**

Sample rules:

- Travel the route R1 and R2, as seen in Figure I, following the map precisely.
- At a stop sign, stop for 3 seconds and then move again.
- At a traffic signal, stop for 5 seconds and then move.

Use Google Docs to record your devised algorithms.

**Teaching Tips:**

- For students good in algorithm design, the teacher can ask those students to devise an algorithm that can traverse the path or give an idea on how this functionality can be achieved.

**Section 2: Running the Program** (45 minutes)

The algorithm devised in Activity 1 is to be converted into a working program on Bloxter. The program is to be written on the bloxter interface opened on a tablet.

- Open the bloxter interface on the tablet. This interface comes up when the smart car is connected to the tablet.
- Use the appropriate command blocks and change the values as per the algorithm and fix them one after the other to complete the algorithm. For example, Figure II shows how the blocks need to be connected to each other. This is the program to traverse R1.
- After writing the program, run the program once or twice to check if it is working properly.
- Now place 2 cars at Franklin Park Mall, one programmed to traverse R1 and the other programmed to traverse R2,
  OR
- Cars could be made to run individually as well.

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Repeat the process 10 times, and record the data in Google Sheets in the format as shown in Fig. 2

| Time | Exp. 1 | Exp. 2 | Exp. 3 | Exp. 4 | Exp. 5 | Exp. 6 | Exp. 7 | Exp. 8 | Exp. 9 | Exp. 10 | Total Time (s) | Average (s) | S.D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time taken on R1 (s) | | | | | | | | | | | | | |
| Time taken on R2 (s) | | | | | | | | | | | | | |

**** (For Instructional Purposes Only) ****
The Average is calculated using the formula:

$$T_{avg} = \frac{\sum T_i}{n}$$

Here, the value of *n* would be 10.
The Standard Deviation is calculated using the formula:

$$S.D. = \sqrt{\frac{\sum (T_{avg} - T_i)^2}{n}}$$

Here, the value of *n* would be 10.

Based on the Average and Standard Deviation, conclude which route was optimum for reaching B from A.

**Teaching Tips:**

- If students came up with a different algorithm or program and it works fine, then let them go with their program. Just check for the values used in the program. They need to be the same as mentioned in the problem.

Section 3: Statistical Analysis (30 minutes)

Represent the data in two different tables for the routes R1 and R2. The tables must contain the given information (speed limits, distance and traffic rules), calculated information (total time/ time taken and standard deviation).

****(For Instructional Purposes Only) ****
The maximum speed of the car is 20.35 in/sec. Convert the speed (given as a percentage) to in/sec and find the total time taken.
Here, the total time taken is calculated using the following formula:

$$T_R = \sum \frac{Distance_i}{Speed_i} + No.of\ stop\ signs \times 3 + No.of\ Traffic\ Lights\ \times 5$$

Where, $T_R$ is the time taken by a specific route R.

Based on the total time taken, determine the best route.

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## Wrap-up: Conclusions and Inferences (10 minutes)

**Activity:**
The following questions can be asked for the wrap-up.

- Which route came out to be the best based on the experiment and the statistical analysis? Were there any differences in the results of the two activities?
- Do you think that what we designed today is the most efficient way of designing an optimum route finder? Can you think of a way to make this process a little dynamic?
- What did we learn in this lesson?

There are a lot of different ways to make the process more dynamic. Like taking input parameters from a database and then finding the best route, instead of programming the car to follow just a specific route.

**Assessment:**
Collect students' reflections. Assess for thoughtful, complete responses and experimental understanding. The students' interest in STEM.

## Learning Objectives and Standards

| Learning Objectives | Standards |
|---|---|
| **LO1**: Analyze a problem and suggest possible solutions. | *Computer Science*<br>CSTA L1:6.CT.6: Understand the connections between computer science and other fields.<br><br>CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them. |
| **LO2**: Identify which route took the minimum time. | *Common Core:*<br>• ***S-IC:*** *Making Inferences and Justifying Conclusions - Make inferences and justify conclusions from experiments, observational studies and sample surveys.*<br>• ***S-ID:*** *Summarize, represent, and interpret data on a single count or measurement variable.* |
| **LO3**: Verbalize a plan (an algorithm) for the whole process. | |
| **LO4**: Code the smart car to run as per the requirement in the question. | |
| **LO5:** See the mathematics behind everyday things. | |
| **LO6:** Make inferences and justify conclusions based on the observations made both by numerical analysis and experimentation. | |

## Additional Information and Resources

### Project-based Learning Features

| Feature | Where does this occur in the lesson? |
|---|---|
| ***Driving Question*** | Here our driving question is what are some of the functionalities that your autonomous paratransit bus should have? The autonomous bus should be able to find the quickest route to reach its destination and should be able to answer whether the passenger will reach on time. |
| ***Making Sense of Data*** | In all the activities we are collecting analytical and experimental data and trying to come up with a conclusion based on it. |
| ***Investigation & Problem Solving*** | Here the students are investigating the quickest route taken and the various technologies involved in finding the quickest route to reach from one place to the other. |
| ***Technology Incorporation*** | The data is stored in google sheets, and most of the information presented is published on Google Classroom. They are also using a smart car prototype to do the experiments. |
| ***Collaborative Opportunities*** | In the Activities designed, the people involved in the lesson are working in groups. They share their ideas and knowledge with each other, leading to Collaborative Learning Opportunities. They are also sharing their results and other observations in Google Classroom where they can see the results of others and learn as a group. |
| ***Assessment*** | Assessment is done on whether the program is achieving the desired functionality, the efficiency |

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| ***techniques*** | of the program, the results obtained, and the conclusions are drawn based on the experiments conducted. |

## Computational Thinking Concepts

| Concept | Where does this occur in the lesson? |
|---|---|
| **Algorithm Design** | In this lesson, all the activities require the use of a computer program for which an algorithm is necessary. In all the activities, we are developing algorithms to make the car achieve a certain functionality. |
| **Pattern recognition** | To follow the routes precisely, a pattern is observed in Activity 2. |
| **Decomposition** | In Activity 2, two programs had to be written. So, the whole problem was first decomposed into 2 parts, one being R1 and the other being R2. And further decomposing each route into separate paths. In Activity 3 and 4, the different scenarios need to be programmed separately by decomposing the problem. |

## Administrative Details

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|---|---|
| **Contact info:** | www.utoledo.edu/research/initiate |
| **Sources:** | Dexter Industries. (2016). *Bloxter*. www.bloxter.com<br>Google Incorporation. (2016). *How Google Maps find the best route for you*. https://www.youtube.com/watch?v=hxI1SmcDBpk<br>Google Incorporation. (2018). *Google Classroom*. classroom.google.com |
| **Date Written:** | 04/20/2021 |
| **Template adapted from:** | https://edu.google.com/resources/programs/exploring-computational-thinking/ |