INITIATE Lesson Plan: *Routes – Investigations for Designing Routes*

Lesson plan at a glance:

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 **Instruction:** 80 minutes
Standards	*Common Core:* • **S-IC:** *Making Inferences and Justifying Conclusions - Make inferences and justify conclusions from experiments, observational studies and sample surveys.* • **S-ID:** *Summarize, represent, and interpret data on a single count or measurement variable.*

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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

	• Check whether all tablets are working, connected to the smart car, and have sufficient battery in them. • The markings on the cardboard must be clearly visible. • 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

Warm-up Activity: Information Gathering and Brainstorming	10 minutes
Activity 1: Speed of GoPiGo	30 minutes
Activity 2: Optimum Route	30 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).

Teaching Tips:
The teacher can use an online discussion board to host these questions where students can actively discuss the warm-up questions with the teacher and peers. The teacher can act as a moderator so that the students can stay on the discussion.

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 can record their experiments in a video and send to the teacher.
- The teacher can use an online portal such as Google Classroom (Google Incorporation, 2018), Blackboard, etc. to create a questionnaire, and the students can submit their answers there.

Activity 1: Optimum Route (30 mins)

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) 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).
2) Based on the Map (Figure 1) displayed to them they will have to devise an algorithm to traverse the route (OPTIONAL)
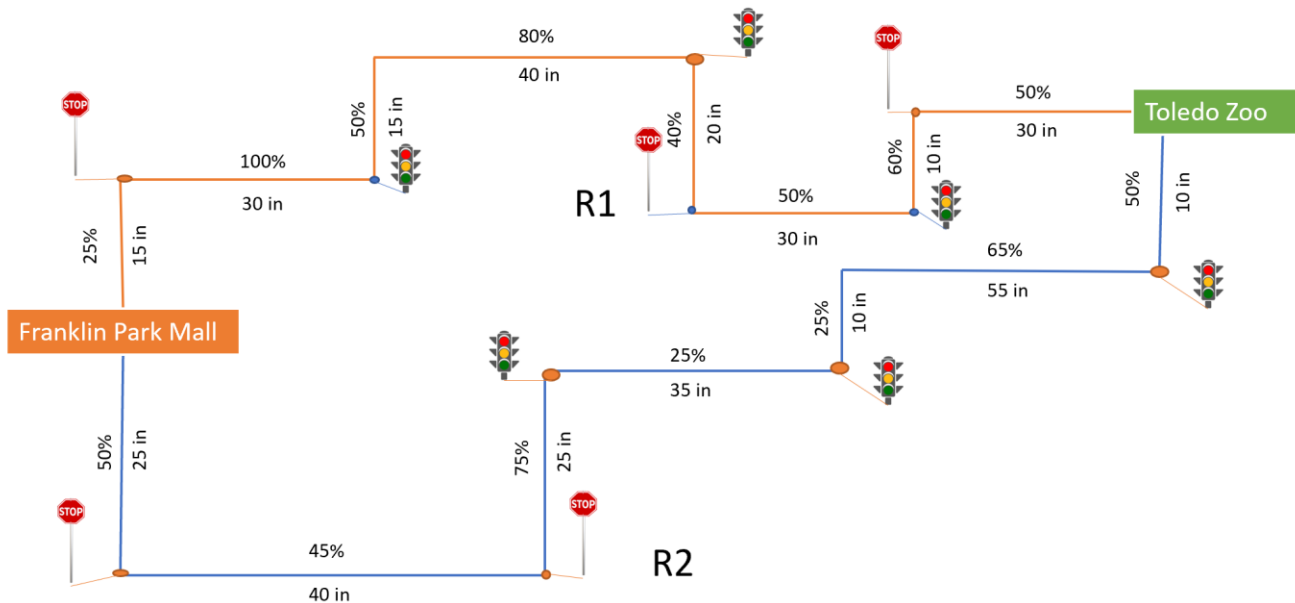3) Program the GoPiGo smart car. (OPTIONAL)

Figure 1

Route R1			Route R2		
Speed(%)	Distance(in)	Time taken (s)	Speed(%)	Distance(in)	Time taken (s)
25	15		50	25	
Stop Sign		3	Stop Sign		3
100	30		45	40	
Traffic Light		6	Stop Sign		3
		$\sum$ time taken			$\sum$ time taken

Solution:

1) **Filling out the Table** (15 minutes)

- In the *Speed (%)* column enter the percentage speeds of each route.
- In the *Distance (in)* column enter the distances given for each path.
- Use the average speed of GoPiGo that you calculated the previous Activity to be the maximum speed of the GoPiGo here. The percentage values can now be converted to *in/s* for all speed percentages.
- Use the Speed-Distance-Time formula to calculate the time for each path on both the routes. 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.
- Sum up the time taken on each path for both routes. The one with lesser value is the quicker route.

2) **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.

3) **Running the Program** (45 minutes)

The algorithm devised in Activity 1 is to be converted into a working program on Bloxter (Dexter Industries, 2016). 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. The two cars can be run separately, and time can be recorded using a stopwatch.

Teaching Tips:
- In case of an online lesson plan, the teacher can skip parts 2 and 3.
- The teacher may give one GoPiGo to some students and ask them to video record their parts 2 and 3 and send it.
- 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.

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* CSTA L1:6.CT.6: Understand the connections between computer science and other fields. CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.
LO2: Identify which route took the minimum time. **LO3**: Verbalize a plan (an algorithm) for the whole process.	*Common Core:* • **S-IC:** *Making Inferences and Justifying Conclusions - Make inferences and justify conclusions from experiments, observational studies and sample surveys.*

LO4: Code the smart car to run as per the requirement in the question.	• **S-ID**: *Summarize, represent, and interpret data on a single count or measurement variable.*
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 techniques	Assessment is done on whether the program is achieving the desired functionality, the efficiency 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

Contact info:	www.utoledo.edu/research/initiate
Sources:	Dexter Industries. (2016). *Bloxter*. www.bloxter.com Google Incorporation. (2016). *How Google Maps find the best route for you.* https://www.youtube.com/watch?v=hxI1SmcDBpk Google Incorporation. (2018). *Google Classroom*. classroom.google.com
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