
INITIATE Lesson Plan: Routes – Designing a route for Autonomous Paratransit Service

Lesson plan at a glance

Name	Routes – Designing a route for Autonomous Paratransit Service
Course	Geometry
Grade level	9 th to 12 th
Prerequisites	Speed, Distance and Time; Angle measurements.
Time	Preparation: 10 to 15 minutes Instruction: 70 minutes
Standards	<u>TPS:</u> <u>Math -</u>

- *G-CO.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.*

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Lesson Overview

Autonomous vehicles are the future of transportation. Various transit agencies are working on using autonomous buses for public transportation, including paratransit services. The paratransit services need some major changes as they are underperforming today. So how would an autonomous paratransit service of future would like? How will the transit agency determine which routes are the best and how will they program these smart buses to run on a fixed route? In this lesson we will design the bus routes for TARPS in the Toledo area. We already have information on what are some of the popular destinations and popular TARTA bus routes and using this information the routes will be planned for Toledo. A prototype of these routes will be traversed using the GoPiGo smart car to emulate a TARPS bus.

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?

Materials and Equipment

- For the student:
 - *Required:*
 - A smart car kit (one (1) kit per x students recommended)
 - An Android tablet connected to the smart car.
 - A cardboard with the map of the routes.
 - Scratch paper
 - Compass
 - GeoGebra
 - Ruler
 - Pencil

Preparation Tasks

	<ul style="list-style-type: none"> • 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
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The Lesson

<u>Warm-up Activity: Information Gathering and Brainstorming</u>	10 minutes
<u>Activity 1: Route</u>	1 hour 20 minutes
<u>Activity 2: Implementing Route on GoPiGo</u>	50 minutes
<u>Wrap-up: Conclusions and Inferences</u>	10 minutes

Warm-up Activity: Information Gathering and Brainstorming (10 minutes)

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

- What are some of the things we need to consider while planning routes?
- What all information do we have?
- What more do we need?

Read the following article (ppiaf.org, 2006):

<https://ppiaf.org/sites/ppiaf.org/files/documents/toolkits/UrbanBusToolkit/assets/1/1d/1d4.html>

- Which system of routes do you think will be optimum for Toledo?
- What types of route should suite Toledo the most?

Read the document from TARTA to get the required information: [TARTA data.docx](#)

Based on the information let us design the route for Toledo.

Activity 1: Route (30 minutes)

Problem Statement: Given the Map of Toledo, identify the potential destinations or stops for the passengers. Design the itinerary for the individual routes which includes the number of buses running on each route, in each hour, the times at which a bus will reach at a destination for pick up and drop off (approx.).

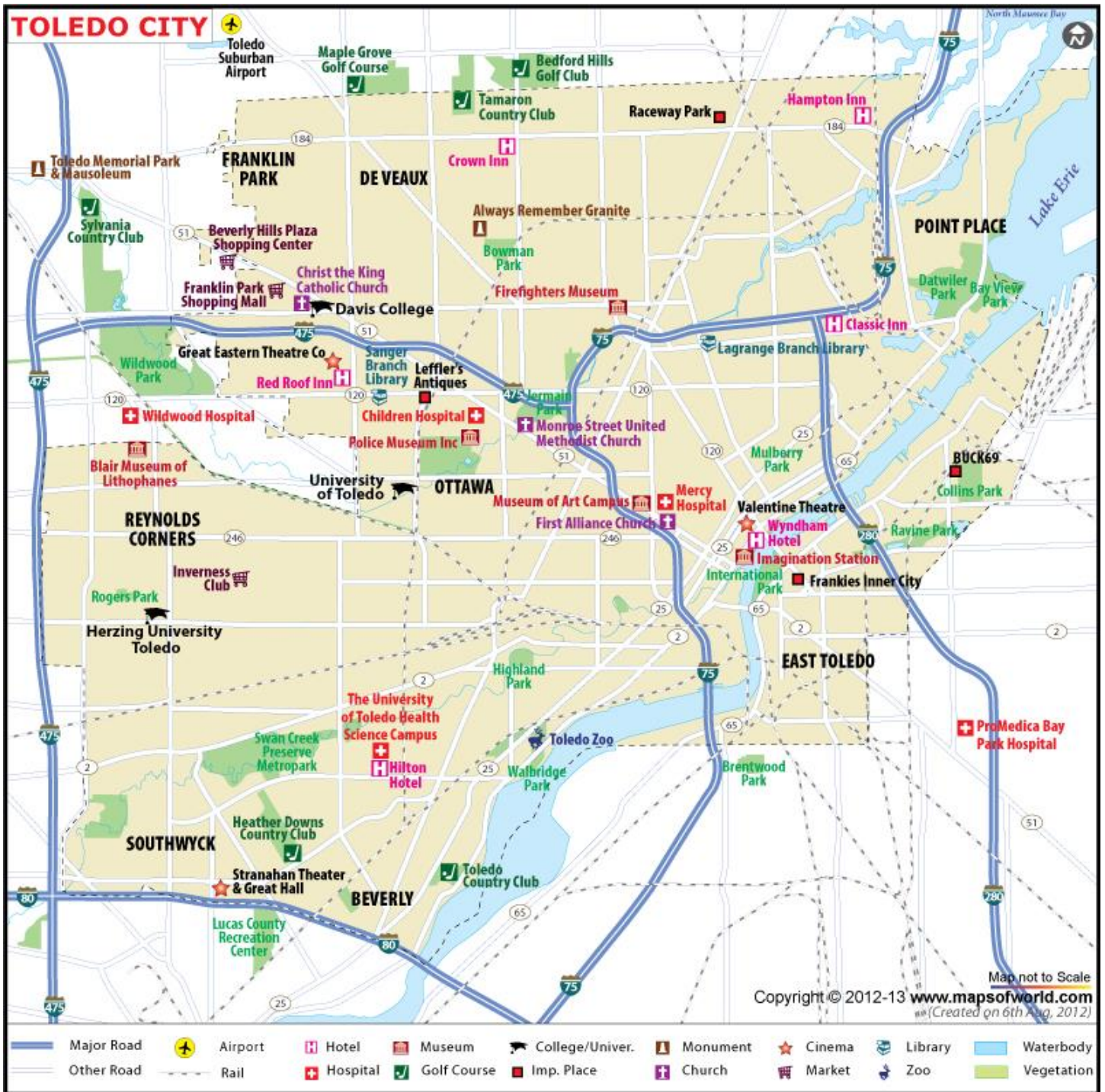


Figure 1

Section 1: Planning (2 minutes)

Divide the class into 4 groups. The map of Toledo is divided into 4 sections given below.

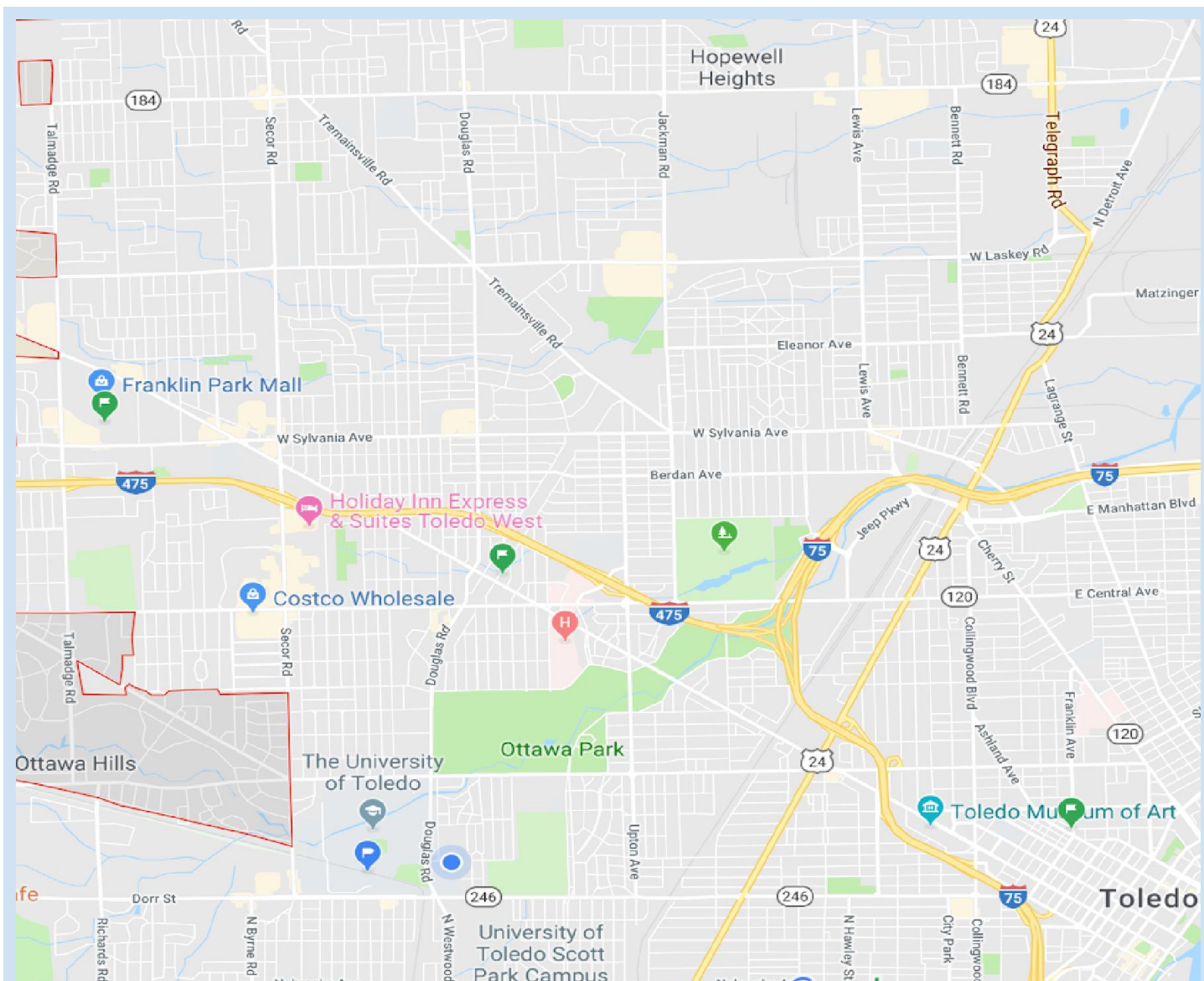


Fig 2: Area 1

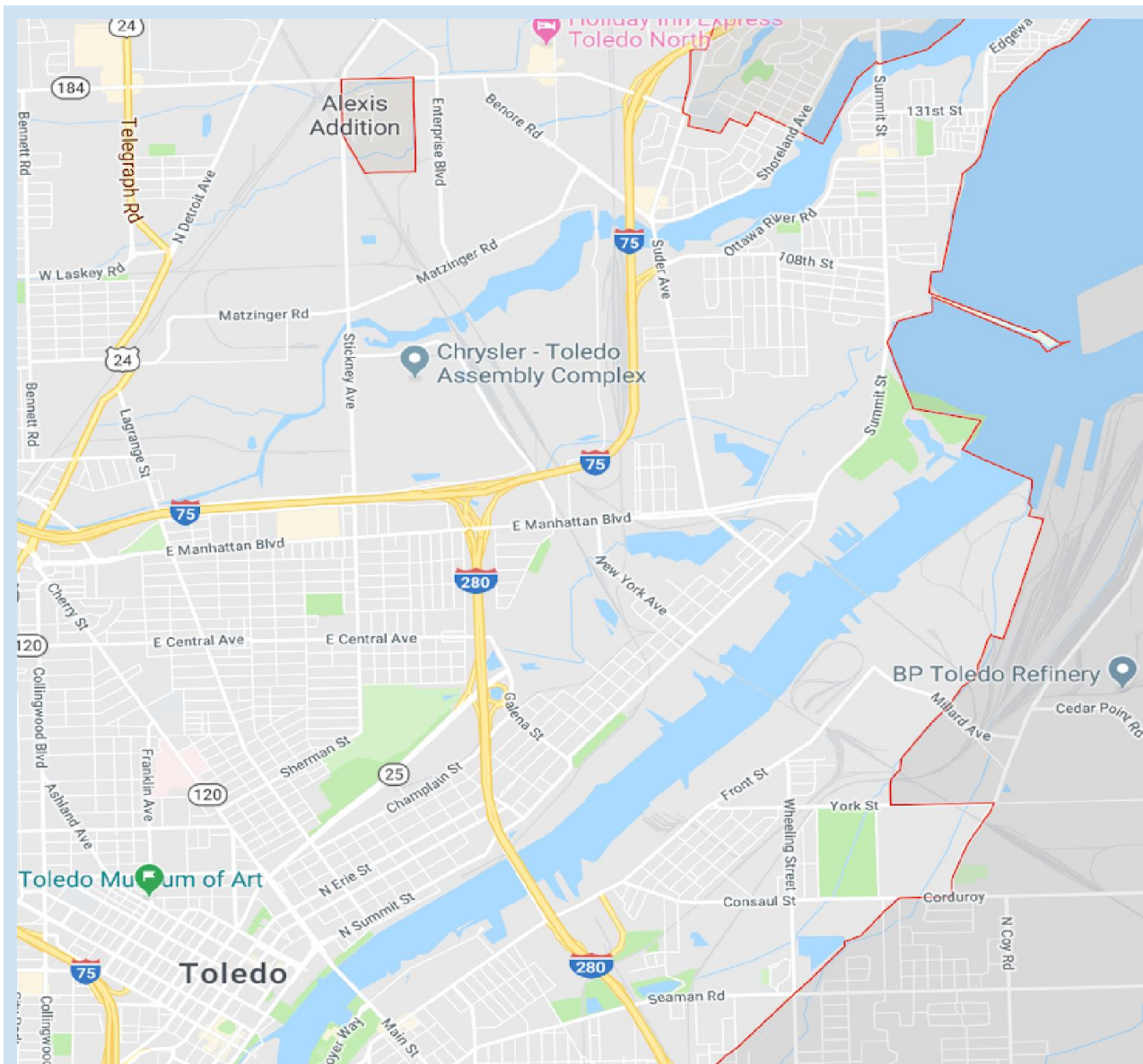
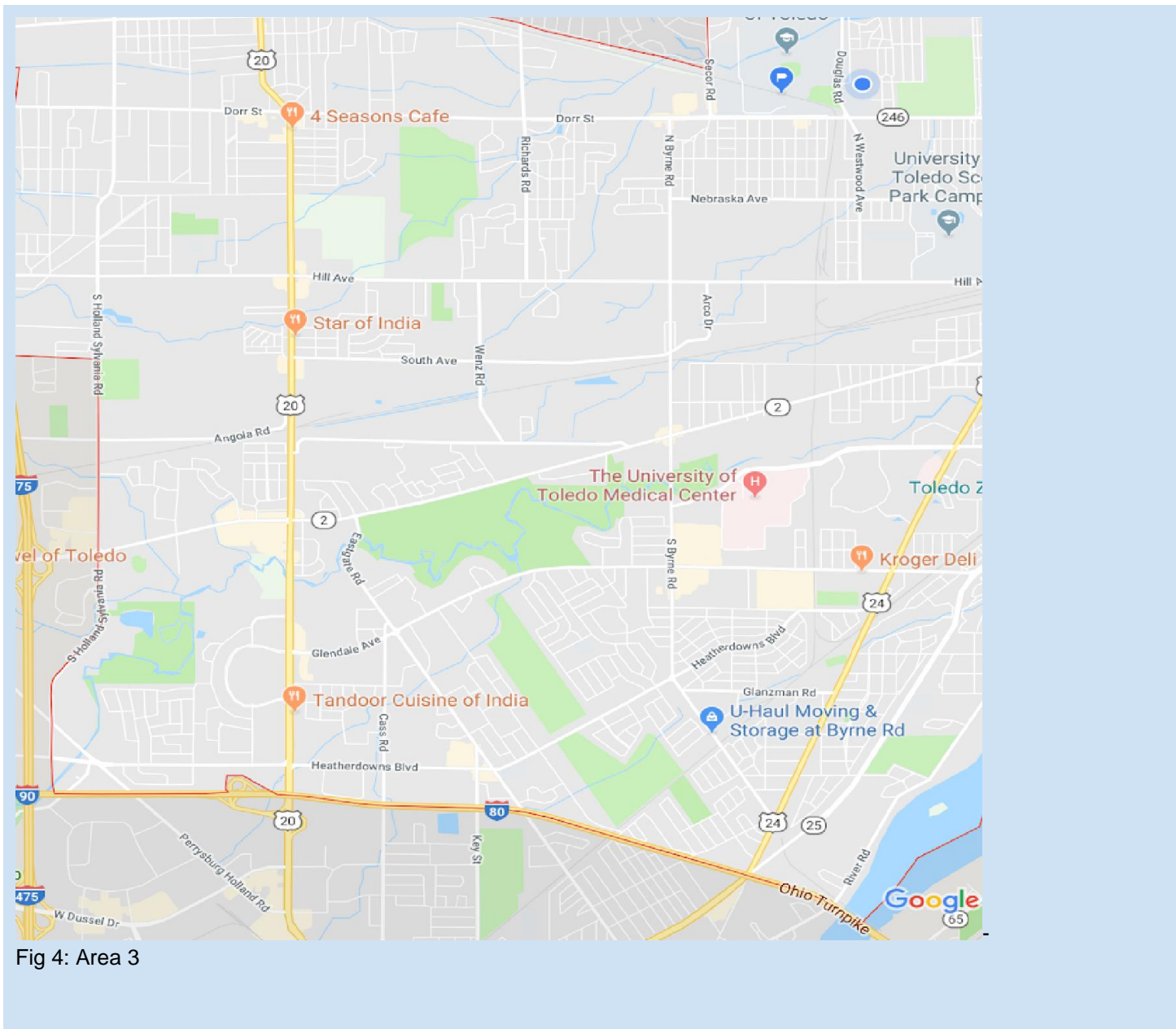


Fig 3: Area 2



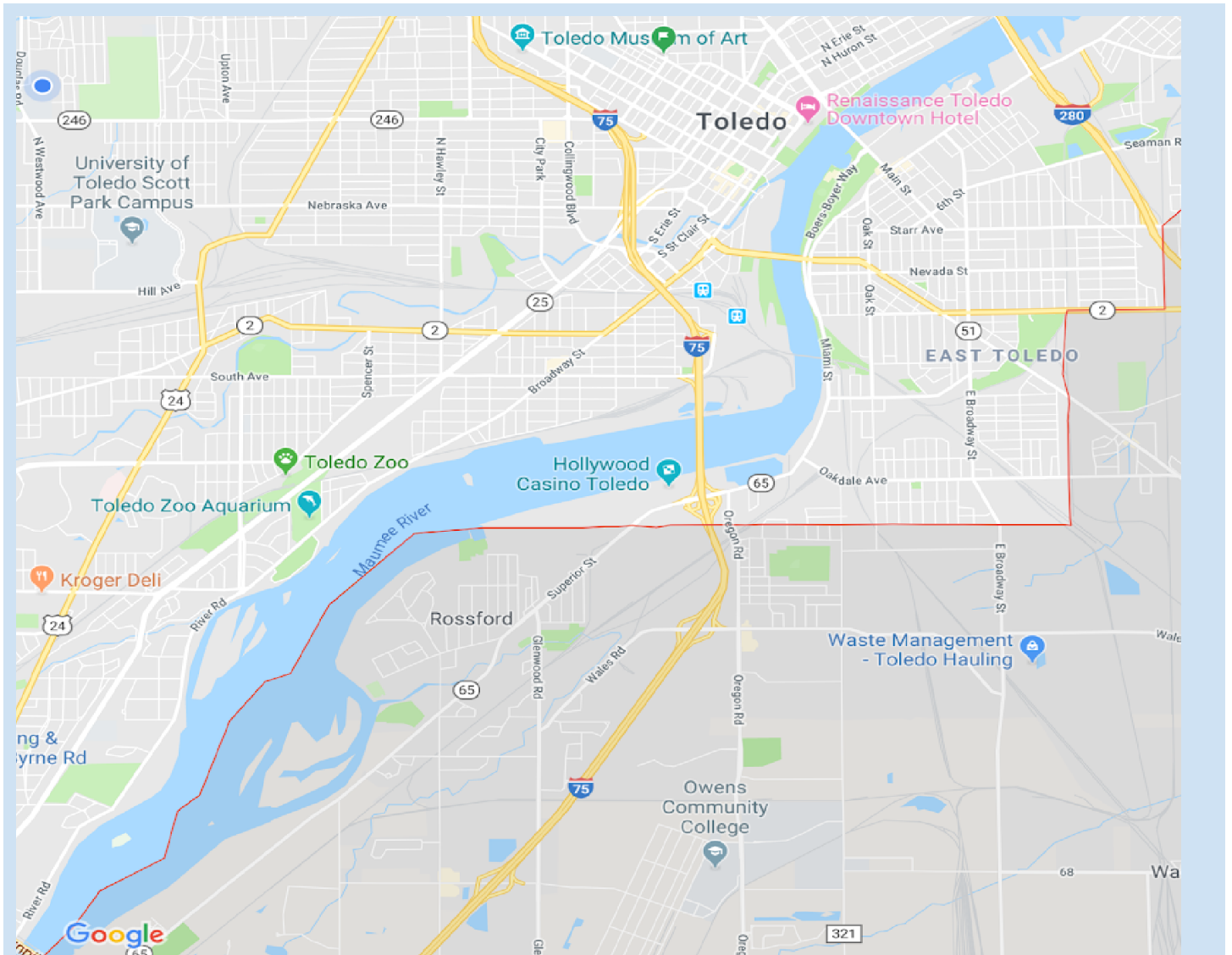


Fig 5: Area 4

Each group gets to work on 1 section of the map.

Teaching Tips:

- Make separate meeting rooms for each of the groups for them to discuss their strategies.
- 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: Selecting popular destinations (20 minutes)

For each section of the Map the students will mark the popular destinations. Based on the information provided by TARTA in the document, the teachers will select some of the popular routes. To give a hint they can visit this link (<http://tarta.com/routes/>) to find the already existing TARTA routes. They will be using google to search for hospitals, shopping centers, malls, schools, workplaces, etc, while once they have selected the routes. Some of the necessary destinations have to be Franklin park Mall, Toledo Museum of Art and Toledo Zoo, Amtrack Train Station, and Toledo Airport. Based on this information they will change the route to suit the needs of people with disabilities and select the number of stops in the route.

Section 3: Finding Time Taken (30 minutes)

Based on the destinations selected, find out the time taken to reach from one point to the other. This can be done using Google Maps. Enter a source and destination and select the route you want to take, then Google Maps will show you the time taken to reach from the source to the destination.

Google

franklin park mall to costco

All Maps News Shopping Images More Settings Tools

About 652,000 results (1.05 seconds)

- Franklin Park Mall, 5001 Monroe St, Toledo, OH 43623
- Costco Wholesale, 3405 Central Ave, Toledo, OH 43606

9 min (2.5 mi) via Talmadge Rd and OH-120 E/Central Ave [Directions](#)

9 min (2.4 mi) via Woodley Rd and Central Ave

10 min (2.8 mi) via I-475 E and Secor Rd

Fig. 6

Record this information in the form of a table. Keep a track of stop signs and traffic signals in the area while calculating the trip time. Number of stop signs and traffic lights can be determined using Google Maps 3D view (Show demo). Considering an average wait time of 1 minute at a traffic signal, and 3 seconds on a stop sign.

Stops	Time (mins)
A-B	10±2
B-C	5±1
...	...
I-J	2
A - J	$\sum time$

Calculate the roundtrip time for the route by multiplying total time taken by 2.

Section 4: Scheduling (30 minutes)

Now that you have determined the time taken for completing each trip, design a schedule for the buses to run, keeping in mind the rush hours, number of passengers and the number of buses running. For rush hours, i.e. 9-11 and 3-6, the minimum number of buses running on a route should be 4, and in the afternoon, the minimum number of buses running should be 2. You can add more if the route is busy.

Stops	9 am – 11 pm	11 pm- 3pm	3 pm – 6 pm
A	9:00, 9:20, 9:40, 10:00, etc.		
B	9:10, 9:30, 9:50, 10:10, etc.		
C	9:15, 9:35, 9:55, 10:15, etc.		
...	...		
J	9:45, etc.		

Teaching Tips:

- Students can share their designed routes on an Online Platform like Google Classroom.

Wrap-up: Conclusions and Inferences (10 minutes)

Activity:

- Is this way the most efficient way of designing a route follower?
- Can we make this process dynamic?
- What are some of the advantages and challenges of using a fixed path 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.	<p><i>Computer Science</i> CSTA L1:6.CT.6: Understand the connections between computer science and other fields.</p> <p>CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.</p>
LO2: Identify which route took the minimum time.	<p><i>Math -</i></p> <ul style="list-style-type: none"> <i>G-CO.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.</i>
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?
<i>Driving Question</i>	This lesson plan has a driving question which asks the attendants to create the itinerary for the autonomous paratransit buses.
<i>Investigation & Problem Solving</i>	A Problem Statement is presented at the beginning of each Activity. These problems are solved in the Activities using an Experimental Approach.
<i>Technology Incorporation</i>	This lesson requires the use of a robot car named GoPiGo (Dexter Industries) and a smart Android Tablet for experimental purposes, and the use of Google Classrooms and other Google products for Evaluation, Cloud Sharing, and Online Activities.
<i>Collaborative Opportunities</i>	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.
<i>Assessment techniques</i>	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 Activity 1 – Section 2, 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 1.
Decomposition	The whole route needs to be broken down into smaller paths which is an example of decomposition.

Administrative Details

Contact info:	www.utoledo.edu/research/initiate
Sources:	ppiaf.org. (2006). <i>EVALUATE YOUR BUS SYSTEM - Factors Influencing Bus System Efficiency / Route Planning</i> . https://ppiaf.org/sites/ppiaf.org/files/documents/toolkits/UrbanBusToolkit/assets/1/1d/1d4.html
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Template adapted from:	https://edu.google.com/resources/programs/exploring-computational-thinking/