

INITIATE Lesson Plan: *Improved Paratransit Services*

Lesson plan at a glance

Name	Improved Paratransit Services
Course	Mathematics
Grade Level	9 th to 12 th
Prerequisites	Graphs.
Time	Preparation: - 10 minutes Instruction: - 1 hr 25 min
Standard(s)	<u>Common Core:</u> -

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Lesson Overview

In this lesson, we will see the types of transportations that are being used in Toledo and the number of people with disabilities using it, the flaws or problems associated with them, and the cost of using these services for the company. After this, the teachers should be able to see the need for a steady, continuous, and timely Autonomous paratransit service.

Driving Questions

Overarching Driving Question:

- How will autonomous vehicles affect people with disabilities in our society?

Lesson Specific Question:

- What are the demographics and needs of differently abled people in Toledo?
 - How can paratransit services be improved by using autonomous vehicles?

Materials and Equipment

- *Required:*
 - Scratch paper
 - Pencils
 - Computer/Laptop/Tablet

The Lesson

<u>Warm-up Activity: Information Gathering and Brainstorming</u>	15 minutes
<u>Activity 1: Investigation – Modes of Transportation</u>	10 minutes
<u>Activity 2: Finding the Population</u>	15 minutes
<u>Activity 3: Pros and Cons of Autonomous Vehicles</u>	15 minutes
<u>Activity 4: Autonomous Vehicles as Cabs v/s Current Cabs</u>	20 minutes
<u>Wrap-up: Conclusions and Inferences</u>	10 minutes

Warm-up Activity: Information Gathering and Brainstorming (15 minutes)

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

Activity: Start off the lesson with the following questions:

- What modes of transportation have you encountered in Toledo, and in Ohio?
- What type of ground transportation is available in Toledo?
- How are the public transit services in some of the cities (not in Ohio) that you have visited?
- How would you compare Toledo transit services to those cities?

All the responses will be recorded on the white board or on the post-it. Can also use online survey or discussion board.

Watch the following video to see the comparison between the transportation provided in San Francisco and Toledo:

https://www.youtube.com/watch?v=J_rWITwpLQA
(Midstory, 2018)

- What transportation is available for people with disabilities? (Fig 1)

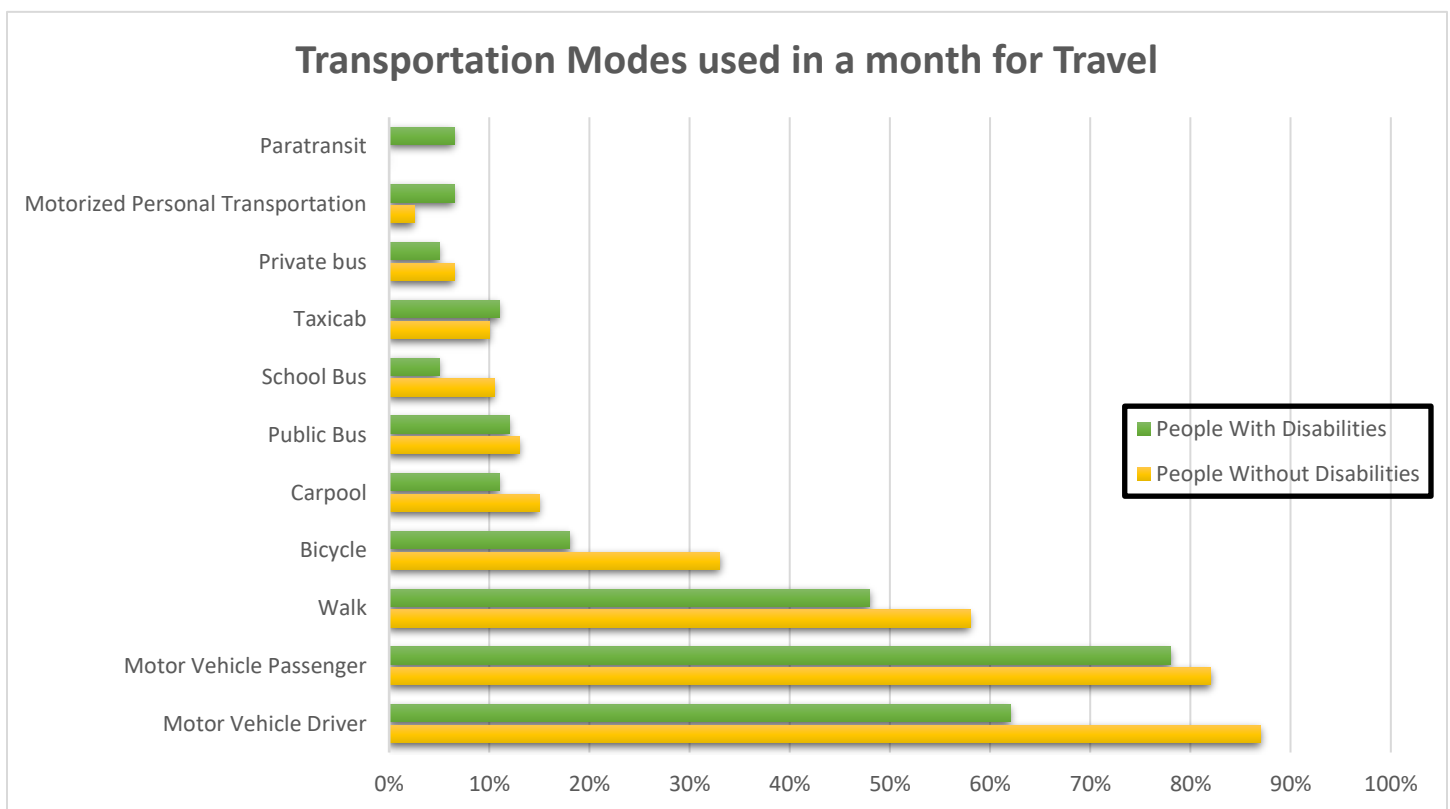


Fig. 1

Activity 1: Investigation – Modes of Transportation (10 minutes)

Problem Statement: Fig. 1 shows the types of transportation used by the people across the nation, and the percentage of the population using them. Identify the Public and Private modes of transportation in them. Investigate the types of public and private transportation available in the applicable categories in Toledo. What do you infer from the given graph? (Follow-up questions) What other trend can be observed in the graph with respect to the modes of transportation used by people with and without disabilities?

Section: Investigation (10 minutes)

1. Investigate the types of public and private transportation available in the applicable categories in Toledo.

The teachers will identify the public and private modes of transportation by looking at the graph.

Public:

- Paratransit – TARPS
- Public Bus – TARTA
- Taxicab – Black and White cabs, Lyft, Uber

Private:

- Motorized Personal Transportation – Motor Bikes, Battery operated scooters, electric wheelchairs
- Private Bus – Anny Grady, TLC transportation, Birmingham Limousine Service
- School Bus
- Carpool
- Bicycle
- Walk
- Motor Vehicle Passenger
- Motor Vehicle Driver

They will then try to find additional transportation agencies by reading the following document from TARTA.

<http://www.tarta.com/wp-content/uploads/2012/10/AppendixBTransportationInventory.pdf> (Toledo Area Regional Transit Authority (TARTA), 2014)

(Important information on page 28)

Here we are Investigating the documents and Making Sense of the Data which are components of PBL.

This information is to be presented.

2. What other trend can be observed in the graph with respect to the modes of transportation used by people with and without disabilities?

People without disabilities use most modes of transportation more than people with disabilities.

3. Is there any exception in the trend? Why is that?

The exceptions are motorized personal transportation, because it includes wheelchairs; and taxicabs, because paratransit services are inefficient. The teachers can do a quick google search with the keyword “TARTA” and look at the ‘Google Reviews’ for TARTA. They have a 3.3-star rating and the reviews are not that great either.

To give an analogy for the increased use of taxicabs by this population, here is a situation of paratransit in East Bay, CA. (KPIX CBS SF Bay Area, 2018)

<https://www.youtube.com/watch?v=Pxgo0xpKrcQ>.

https://www.google.com/search?rlz=1C1JZAP_enUS762US762&ei=nIPQXO_sHuyMtgWVhai4Dw&q=tarta&oq=tarta&gs_l=psy-ab.3..35i39l2j0i67l8.121308.122083..122383...0.0..0.143.542.2j3...2..0....1..gws-wiz.....0i71j0i131j0.nFcvttYFIoo&npsic=0&rflfq=1&rlha=0&rllag=41658780,-83553341,2560&tbs=lcl&rdimm=10858597734955514435&ved=2ahUKEwjp4P2cy4fiAhUGC6wKHbVzBFEQvS4wAXoECAYQHA&rdoc=1&tbs=lr:!2m4!1e17!4m2!17m1!1e2!2m1!1e16!3sIAE,lf:1,lf_ui:3#lrd=0x883b86dd82d5e461:0x96b17d1bcee27a43,1,,,&rifi=hd::si:10858597734955514435;mv:!1m2!1d41.680101099999995!2d-83.5317132!2m2!1d41.6374606!2d-83.6109083;tbs:lr:!2m1!1e16!2m4!1e17!4m2!17m1!1e2!3sIAE,lf:1,lf_ui:3

The services are inefficient because of added rides and inappropriate behavior of the staff.
 How can we make these services better and timelier? – autonomous vehicles, and fixed route services.

This information is to be presented.

Have a discussion that the tradeoff b/w reaching on time and getting picked up from their home is needed, and fixed routes are a necessity. (Can be done on a Discussion Board if necessary)

Here we are Investigating the documents and Making Sense of the Data which are components of PBL.
 Here we had a discussion on why we need to have a tradeoff. This kind of discussion is a part of collaborative opportunities in PBL.

Teaching Tips:

- If the teachers find other modes of transportation, or other reasons and findings, include them as well.

Activity 2: Finding the population (15 minutes)

From the graph above, create a table of the approximate percentage values for different modes of transportation. Find the number of people with disabilities using paratransit services in Toledo.

To complete this activity, the approximate percentage values can be made.

Mode Of Transportation	People Without Disabilities	People With Disabilities
Motor Vehicle Driver	87%	62%
Motor Vehicle Passenger	82%	78%
Walk	58%	48%
Bicycle	33%	18%
Carpool	15%	11%
Public Bus	13%	12%
School Bus	10.50%	5%
Taxicab	10%	11%
Private bus	6.50%	5%
Motorized Personal Transportation	2.50%	6.50%
Paratransit	0.00%	6.50%

Step 1: From the previous questions, the total disabled population can be calculated:
 Do a quick search to find out the population of Toledo Ohio.

Total Population of Toledo = 276,491,
 % of disabled population in OH = 13.9%

$$\text{Number of Disabled in Toledo} = \frac{13.9}{100} \times 276491 \approx 38,432$$

Step 2: Now we calculate number of people using paratransit:

Number of Disabled in Toledo = 38,432

% of disabled population using paratransit = 6.50%

Number of Disabled people using paratransit in Toledo = $\frac{6.5}{100} \times 38432 \approx 2498$

This information is to be presented.

Here is the point where we use abstraction, a concept of CT. Out of all the information presented in the table we are using just one, which is paratransit services.

Activity 3: Pros and Cons of Autonomous Vehicles (15 minutes)

Problem Statement: With the transportation companies not providing desired services and the large population of people with disabilities that need these transportation services, there arises a need to switch to Autonomous Vehicles (AVs). But we need to find what are the pros and cons of AVs. So, read the document “Autonomous Vehicles Implementation Predictions (Pages 1-4)” and identify the pros and cons of AVs for people with disabilities. Record your answers in the form of a table with 2 columns named ‘Pros’ and ‘Cons’.

Advantages of self-driving cars	Disadvantages of self-driving cars
<ol style="list-style-type: none">1. Reduces chauffeuring burdens on their family members and friends.2. Improve their access to education and employment opportunities.3. Increase economic productivity.4. Decrease paratransit cost (the average one-way paratransit trip cost in the 50 largest U.S. transit agencies was \$29.28 or 47\$ in Cleveland https://www.ncbi.nlm.nih.gov/books/NBK11420/)5. Shared autonomous vehicles will be cheaper than human- operated ride-hailing and taxi services (Table 1.2).6. AV's in a ridesharing fashion will significantly have lower waiting time.7. AV's will be occupied with the most sophisticated communication systems which can be tracked online.8. Such reliable transportation will guarantee a person with disability will be able to make it to her-his medical appointment. Indeed , 11.2 million medical appointments are missed annually by individuals with disabilities due to inadequate transportation (The Ruderman White Paper,2017)	<ol style="list-style-type: none">1. Autonomous vehicles level 5 (AV's) are not available on the road as of today.2. Since there will not be driver on board passengers may still encounter previous occupants' garbage, stains and odors.3. In comparison with human driven paratransit services, AV's will add delay for each additional passenger considering the pickup and drop-off delays, particularly for passengers with special needs.4. The Artificial intelligence that AV's are occupied with may not meet the needs for all different disabilities.

Here is the point where we use abstraction, a concept of CT. Out of all the information presented in the table we are using just one, which is paratransit services.

We are Investigating and finding relevant information from a source, an important part of PBL

Teaching Tips:

- The teachers can provide tips on where to find relevant information

Activity 4: Autonomous Vehicles as Cabs vs Current Cabs (20 minutes)

Section 1: Current Cabs (10 mins)

Problem Statement: Keeping the current cab fares in mind, would autonomous vehicles be better or worse as cabs for people with disabilities? Calculate how much would a round trip taxi cost from your home to the nearest hospital. How much would it cost if you go there twice a month?

Solution: Using a website <https://www.taxifarefinder.com/> we calculate the trip from home to nearest hospital. This trip is from 711 Pine Valley Lane to ProMedica at 100 Madison Ave, Toledo, Ohio, 43604 which is 7.7 mile.

The screenshot displays the Taxifarefinder website interface. On the left, the 'Estimated Fare' is \$21.55, with a note that the total cost including a 15% tip is \$24.78. Below this, a 'Cost with Traffic' bar shows a range from \$19.89 to \$28.84, with \$21.55 highlighted. The 'Fare Information' section includes trip details: 7.7 miles, 19 minutes. An 'Approximate Breakdown' table shows: Initial Fare (\$2.00), Add. Metered Fare (\$19.55), Tip (15%) (\$3.23), and Estimated Taxi Fare (\$24.78). The main map area shows a route from point A (711 Pine Valley Lane) to point B (ProMedica) in Toledo, Ohio. At the bottom, there are input fields for the start and end addresses and a 'Get Fare!' button.

The cost for a round trip:

$$\$21.55 \times 2 = \$43.10$$

So, it would cost **\$43.10** for one hospital visit. Since one is going there twice a month, it would be \$86.20 for each month.

Section 2: Trip Cost Using Autonomous Vehicles in a Ride-sharing Fashion (10 mins)

Problem Statement: Several works have been done by researchers to determine how much it would cost to ride in an AV cab in a ride sharing fashion. Some of the works are stated in Table 1 below. Pick three different studies from the table and take the average to see how much AV in a ride-sharing fashion can cost. Ashley has a physical disability and

must see her doctor twice a month. If she were to use the AV instead of a regular cab, then using the cost calculated in the previous question how much would she spend in a month on the AV fares on 13.7 miles roundtrip?

cost estimates analysis of future transport services with AVs in a ride-sharing scheme per passenger-mile			
Researcher's name	Year that study was published	The estimated lowest cost (\$)	The estimated highest cost (\$)
Burns et al.	2013	0.15	0.15
Fagnant and Kockelman	2014-2015	0.50	1.00
Litman	2015	0.60	1.00
Johnson	2015	0.44	0.44
Stephens et al. and Friedrich and Hartl	2016	0.20	0.30
Johnson and Walker	2016	0.20	0.30
Bösch, et al.	2017	0.20	0.40
Keeney	2017	0.10	0.10
Kok et al.	2017	0.10	0.10

Solution: If we consider Johnson, Stephens, and Bosch et. al.'s study, then the total round trip costs are listed

Name	Price per mile	Length of trip	One Round Trip	Total for Month
Johnson	\$0.44	13.7 mile	\$ 6.03	\$12.06
Stephens	\$0.30	13.7 mile	\$ 4.11	\$8.22
Bosch et al	\$0.40	13.7mile	\$ 5.48	\$10.96

below:

Therefore, the average of cost for a month using Autonomous Vehicles would be approx. **\$10.42.**

Wrap-up: Conclusions and Inferences (5 minutes)

- What have been the potential impacts of inadequate services?
- Are there any potential benefits for using autonomous vehicles for paratransit, with respect to the cost to the rider?
- Will companies benefit from it, too?
- Once AVs are perfected, what would be the next step to design a paratransit system?

This wrap up shows how much could people with disabilities save if AVs become the norm.

Assessment:

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

Learning Objectives

Learning Objectives
LO1: Students will be able to analyze a problem and suggest possible solutions.
LO2: Students will be able to identify the are the various public and private transportation services in Toledo.
LO3: Students will be able to verbalize a plan (an algorithm) for solving the Activity 4
LO4: Students will be able to identify the various components of PBL and Computational Thinking.
LO5: Students will be able to see the mathematics behind everyday things.

Additional Information and Resources

Project-based Learning Features

Feature	Where does this occur in the lesson?
Driving Question	The Driving Question can be seen at the very top after defining the Lesson Objective. In this lesson, we answered who is using the paratransit services, and which paratransit service would be better, the one running today, or future AV ride sharing cabs.

<i>Making Sense of Data</i>	Data shown in the chart in Activity 1 is converted in the form of a table, and the data collected in Activity 2 section 2 is represented in the form of a table. This form of learning is an essential form of PBL.
<i>Investigation & Problem Solving</i>	A Problem Statement is presented in the beginning of each Activity. These problems are solved in the Activities using a Theoretical Approach.
<i>Technology Incorporation</i>	This lesson requires the use of Google Classrooms (Google Incorporation, 2018) and other Google products for Evaluation, Cloud Sharing, and Presentation.
<i>Collaborative Opportunities</i>	In both the Activities designed, the people involved 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 results obtained are correct or not and whether the approach used was aligned to obtain the result.

Computational Thinking Concepts

Concept	Where does this occur in the lesson?
Abstraction	In Activity 1 and Activity 2 section 2, selective pieces of information are useful in the table and the document respectively for solving our problem. The most relevant piece of information is taken from the table and the document, and the rest is ignored.

Administrative Details

Contact info:	www.utoledo.edu/research/initiate
Sources:	Google Incorporation. (2018). <i>Google Classroom</i> . classroom.google.com KPIX CBS SF Bay Area. (2018). <i>KPIX Investigation Reveals Deeps Flaws In Paratransit Services</i> . https://www.youtube.com/watch?v=Pxgo0xpKrcQ&ab_channel=KPIXCBSSFBayArea Midstory. (2018). <i>TOLEDO ON THE MAP: San Francisco and Public Transportation</i> . https://www.youtube.com/watch?v=J_rWITwpLQA Toledo Area Regional Transit Authority (TARTA). (2014). <i>APPENDIX B: TRANSPORTATION PROVIDERS</i> . TARTA. http://www.tarta.com/wp-content/uploads/2012/10/AppendixBTransportationInventory.pdf
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