Aiming Into the Box

Lesson Summary

Looking at data around us, such as sports statistics and news reports, students will explore different ways to represent, analyse, and understand data, including quartile values and box plots. This lesson builds on, and incorporates, students' [prior knowledge from Grade 8](#).

Grade: 9

Big Ideas

Critical mathematical thinking skills, data analysis, data representation, interpreting data

Learning Expectations

AA1. develop and explore a variety of social-emotional learning skills in a context that supports and reflects this learning in connection with the expectations across all other strands
  - developing a healthy mathematical identity through building self-awareness
  - developing critical and creative mathematical thinking skills

A1. apply the [mathematical processes](#) to develop a conceptual understanding of, and procedural fluency with, the mathematics they are learning
  - communicating
  - representing

A2. make connections between mathematics and various knowledge systems, their lived experiences, and various real-life applications of mathematics, including careers

D1. describe the collection and use of data, and represent and analyse data involving one and two variables

  D1.1 identify a current context involving a large amount of data, and describe potential implications and consequences of its collection, storage, representation, and use

  D1.2 represent and statistically analyse data from a real-life situation involving a single variable in various ways, including the use of quartile values and box plots

D2. apply the process of mathematical modelling, using data and mathematical concepts from other strands, to represent, analyse, make predictions, and provide insight into real-life situations

> **D2.1** describe the value of mathematical modelling and how it is used in real life to inform decisions
>
> **D2.4** determine ways to display and analyse the data in order to create a mathematical model to answer the original question of interest, taking into account the nature of the data, the context, and the assumptions made
>
> **D2.5** report how the model can be used to answer the question of interest, how well the model ts the context, potential limitations of the model, and what predictions can be made based on the model

Cross Curricular Connections

Canadian and World Studies: Geography
- Geography: Students will develop their spatial skills as they analyse information and data obtained from diverse sources, including field studies, aerial photographs, satellite imaging, various types of maps and graphs, geographic information systems (GIS), and digital representations (MOE, 2018, p. 11).
- The Inquiry Processes in Geography: The inquiry process consists of five components:
  - formulating questions
  - gathering and organizing information, evidence, and/or data
  - interpreting and analysing information, evidence, and/or data
  - evaluating information, evidence, and/or data and drawing conclusions
  - communicating findings and/or plans of action (MOE, 2018, p. 27)
- Critical thinking and critical literacy in Canadian and World Studies: In Canadian and World Studies, students who are critically literate are able, for example, to actively analyse media messages and determine potential motives and underlying messages (MOE, 2018, p. 53)

Science
In Science students will learn to apply in scientific investigation skills, including:
- **Analysing and interpreting skills** include evaluating the adequacy of the data from inquiries or the information from research sources, and analysing the data or information in order to draw and justify conclusions.
- **Communication skills** include using appropriate linguistic, numeric, symbolic, and graphic modes of representation, and a variety of forms, to communicate ideas, procedures, and results (MOE, 2008, p. 19).

Learning Goals and Success Criteria:

LG1: We are learning to analyse and use data to tell stories in a real world context.
> SC1: I can analyse data and determine the story it is telling.
> SC2: I can use data to make decisions about a real world context.

LG2: We are learning to organize collected data and represent it in various ways.
  SC1: I can determine what data needs to be collected.
  SC2: I can determine how to organize data in helpful ways.
  SC3: I can represent data.
  SC4: I can make connections between different ways of representing data.

LG3: We are learning to organize and represent data using box plots.
  SC1: I can determine and understand measures of central tendency and quartile values.
  SC2: I can read data and use it to create a box plot.
  SC3: I can interpret and communicate the different components of a box plot.

LG4: We are learning to recognize misleading data.
  SC1: I can communicate how a graph/data is trying to mislead me.
  SC2: I can communicate the real story of misleading data.

CONSIDERATIONS THROUGHOUT THE LESSON

Differentiated Instruction and Universal Design for Learning
- **Flexible Groupings**: Use Flexible Groupings (both homogeneous and heterogeneous) throughout the lesson. (Page 23 from [High-Impact Instructional Practices in Mathematics](#))
- **Five Practices:** Engage in the Five Practices for Orchestrating Productive Mathematical Discussions (Smith & Stein, 2011) in order to anticipate different students' solutions and to lead rich conversations in your classroom. For more on the Five Practices visit the [Math4theNines](#) website.
- **Student Choice**: Students will choose to represent data in ways that make sense to them and the teacher can use flexible groups to select appropriate graphs and data sets for different students and their needs. The use of student choice ensures accessibility for all students.
- **Class Space:** Consider arranging the room in groups of three while creating space for students to brainstorm on whiteboards.
- **Technology Accessibility**: This activity is enhanced with technology. Consider allowing students to use their personal devices or class sets of mobile devices when creating graphs and analyzing the data
- **Document evidence of learning**: use the provided [assessment mapping](#) tool to document evidence of student learning.

Assessment

Throughout the lesson, the teacher will be listening for students to correctly and effectively analyze, interpret, and communicate their thinking about the data that is presented to them and make connections between different representations. The teacher will use observations and conversations throughout the different lesson components as assessment for, as, and of learning.

The Gallery Walk will provide the teacher an opportunity to observe students' work, collect evidence of student thinking and understanding, and to listen to students communicating their thinking about different representations. The teacher may want to consider if the students can provide justification for their choice of representation of the data and if they are able to explain how different representations are similar and/ or different.

The creation of box plots from reading data from misleading graphs will provide teachers the opportunity to collect evidence of students' understanding of the different learning goals of the lesson including reading data; creating box plots; understanding, interpreting, and explaining different components of a box plot; and understanding and describing why graphs can be misleading.

An outline mapping assessment strategies to different components of the lesson, as well as success criteria, is available in the [Supplemental resource document](#) for this lesson.

RESOURCES AND LEARNING ENVIRONMENT

Educator Resources Needed

Educators will need:
- A video depicting the basketball player Stephen Curry shooting shots from all over the court. We suggest using youtube to find a 2-3 minute video. Teachers may want to substitute an alternate player
- A graphic of Stephen Curry's (or another player's) shooting percentage
- [Supplemental resource document](#) with different graphical representations of data
- An empty, clean box or similar container that can be used to throw paper into scrap paper for students in the class to crumple up and throw into container (these can be reused for each student in a group)
- Tape to mark a line on the floor approximately 4-5 m (15 ft) from the container
- Optional: technology such as [Google Sheets](#), Excel, [Jamboard](#), Padlet

Student Materials Needed

Students will require a safe space to conduct their basketball experiment with a line marked clearly on the floor.

Learning Environment Considerations
- This lesson will employ several different learning environments: individual student working time, small groups sorted randomly, whole group discussions, and direct teaching. These different environments are indicated clearly in different parts of the lesson content described below.
- This lesson will include the physical act of shooting balls of crumpled up paper into a container a defined distance away. Prior to class, determine the space that you have in your classroom or elsewhere in your school, and determine the distance students will shoot the paper from. We suggest a distance of approximately 4-5 m (15 ft).

LESSON CONTENT

Minds-On (15 Minutes)

Part 1: Highlight Reel

What Do You Notice/What Do You Wonder? (Students work individually to provide responses to the teacher.)

Show a [highlight reel] of Stephen Curry (NBA basketball player) shooting in a basketball game. Ask students what they notice about the shots that the player takes. Have students share their responses using technology such as a Padlet or Jamboard, using stickies or by simply stating their answers to you to write down for the class to see. Most responses will include something about the fact that he is an incredible shooter, that he doesn't seem to miss, etc.

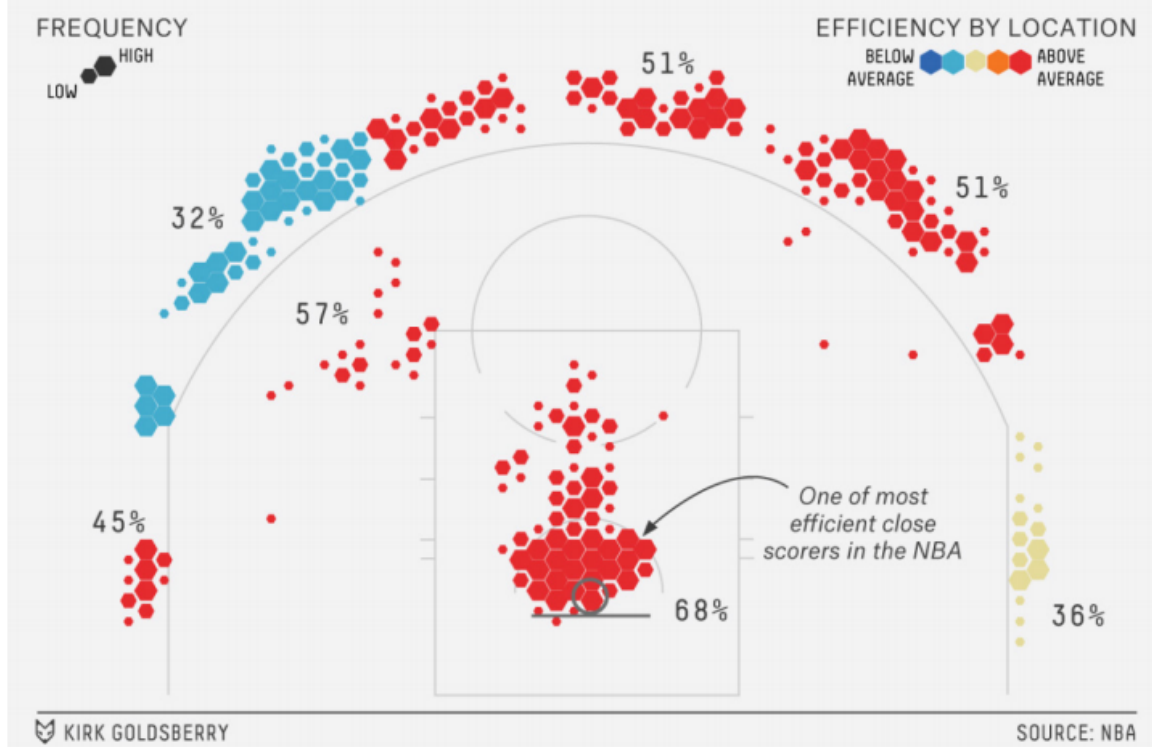## Part 2: What Do You Notice/What Do You Wonder?

What Do You Notice/What Do You Wonder? (Students work in visible random groups to discuss their ideas.)

After students share their notices and wonders from the Stephen Curry highlight video, create the Random Visible Groups for teams of three and direct student groups to stand at a vertical, non-permanent surface (if possible) to receive a verbal explanation of the task. Next, share the graphic below on a screen visible to the whole class and ask the following questions:
- What do you notice/wonder?
- Does this data show a story? If so, what story does it tell you? If not, why do you think it is not telling a story?
- How could you use this data differently if you were the General Manager, Coach, Opposing Coach, Player, or Fan?

Stephen Curry Is One Of The Best
All of his shots, 2015-16 regular season

FREQUENCY — HIGH / LOW

EFFICIENCY BY LOCATION — BELOW AVERAGE / ABOVE AVERAGE

51%

51%

32%

57%

One of most efficient close scorers in the NBA

45%

68%

36%

KIRK GOLDSBERRY

SOURCE: NBA

Source https://fivethirtyeight.com/features/stephen-curry-is-the-revolution/

Part 3: Would You Rather? (Students work in same groupings)

Share this data with the class and ask students to justify which player they would rather have on their team. Ask why they would choose that player. How did they make this decision? This problem will be revisited in the Consolidation section.

The table below displays the free throw percentages for the past 8 years of three basketball players.

Player A Free Throw %	Player B Free Throw %	Player C Free Throw %
59	74	62
78	76	97
81	81	95
98	72	45
63	71	85
72	83	72

93	82	68
79	84	99

Action (75 Minutes)

Part 1: Aiming Inside The Box Task: Introducing The Task

Introduce the task by discussing what free throw means in basketball and define the free throw percent (FT%) stat used for basketball players. Ask a student to describe what a free throw is and where it is taken from. A free throw is an unobstructed shot taken from the free throw line by a player that has been fouled by the other team. Provide an example to activate prior knowledge:

- Alex has taken 36 free throws this season and they have made 24 of them. What is their free throw percentage?

The teacher can decide to show a video of players shooting a free throw. Next, introduce the task by discussing that they will be determining their own free throw percentage while organizing and analyzing the class' free throw data. This data will tell a story.

Part 2: Aiming Inside The Box Task: Collecting The Data

In this activity, each student will perform a basketball free throw simulation. Each student will take 10 shots using crumpled paper balls into a box from a predetermined distance (use a distance of approximately 4 - 5 metres/15 feet). Students will record the number of shots that went into the box in ten attempts. This value will be recorded in a class database (Google Sheets, Excel, Jamboard, Padlet) or given to the teacher to collect. Ensure that the following remains consistent for every student: the crumpled paper ball, the container/box size and the distance each student is shooting from. The need for collecting all this data in the exact same way is an important conversation to have with students.

Part 3: Aiming Into The Box Task: Organizing The Data & Gallery Walk

Once all the students submit their data to the class database, have them organize the data in any way they see fit. Students will need to display their data representation in a way that can be easily viewed by other groups of students when participating in the upcoming gallery walk.

As students are organizing their data, the teacher can use the Five Practices for Orchestrating Productive Mathematics Discussions strategies:

1. Anticipate
The teacher can expect the following (Be prepared to discuss the pros and cons of each representation):

- Data sorted in a list from highest percentage to lowest percentage
- Calculation of mean, median and mode
- Histograms
- Pie Charts to Compare Range of Data
- Scatter plots
- Bar graph of each group member

2. Monitor

As students are organizing the data, monitor the prior knowledge they bring to the class.
- Organizing the data as a table
- Data Visualization: Histograms, circle graphs, pictographs
- Measures of Central Tendencies: mean, median and mode
- The range of the data

At this point the teacher can move around and ask assessing and advancing questions:
- How can you organize the table? (sorting)
- What are other ways to make this data visual? (Histogram, circle graph, pictograph)
- What are the measures of central tendencies? How can they be useful?

3. Select

The teacher should select student work to share that provides different methods and perspectives, making sure to honour, and highlight a variety of student voices.

4. Sequence

Once the teacher has selected a number of solutions to share, the solutions could be sequenced in different ways (it is recommended that you don't start with error-ridden solutions and progress to correct solutions):
- Share the most common strategy first
- Progress from concrete to abstract (it is ok if some of the shared work is not complete)
- Address common misconceptions first
- Share a unique approach first or last

5. Connect

At this point the teacher will connect the various representations of data to the goal. Use the representations that focus on sorting the data chronologically, measures of central tendencies and data range. How can we use this to tell a story?

Allow students to observe all other student work when the task is complete by engaging in a gallery walk. As groups walk around and observe the work of other groups ask them to compare and pay attention to how each team displayed their data: What is similar? What is different?

Part 4: Aiming Into The Box Task: The Box Plot-Direct Instruction

The teacher will display the class set of data from the free throw activity in a box plot that the teacher will have created while students worked in their groups. The teacher can use
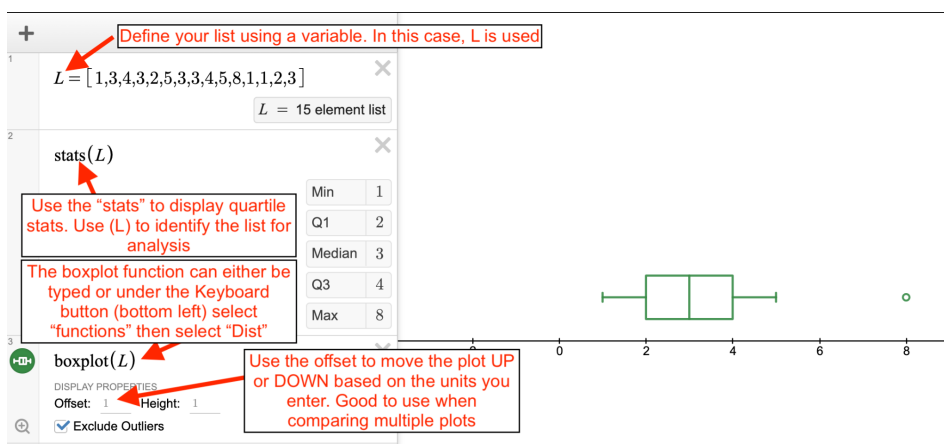
both a pencil and paper method and technology. Emphasize the fact that these plots are used to visualize single variable data and data variance (measure of spread).

Paper and Pencil Methods
- Statistics Canada "Constructing box and whisker plots":
    - Statistics: Power from Data! Box and whisker plots

- Youtube Video "How To Draw a Box Plot":
    - https://www.youtube.com/watch?v=mhaGAaL6Abw

Using Technology: Desmos
- Youtube "How To Create Box Plots and Label Quartiles in Desmos": https://youtu.be/smvuHhPQO0Q
- The image below demonstrate how to create a Box Plot using Desmos

Have students "unpack" what the box plot is, the data it is displaying, and what the different components of the box plot represent. Ask them to compare the box plot to the different representations different groups used to display their set of data. Are there any connections?

Use a different set of single variable data to demonstrate how to create a box plot with the students.
Example: The following data represents the average time (over ten days) it takes students to get to their math class from the previous period.

$$2, 3, 2, 4, 6, 1, 3, 5, 3, 7$$

Use the Teacher Desmos link below to create a class Desmos activity to allow students to investigate Box Plots
https://teacher.desmos.com/activitybuilder/custom/60bd3c337572970ea298184f?collections=60bd44b15d42e835e910b04b
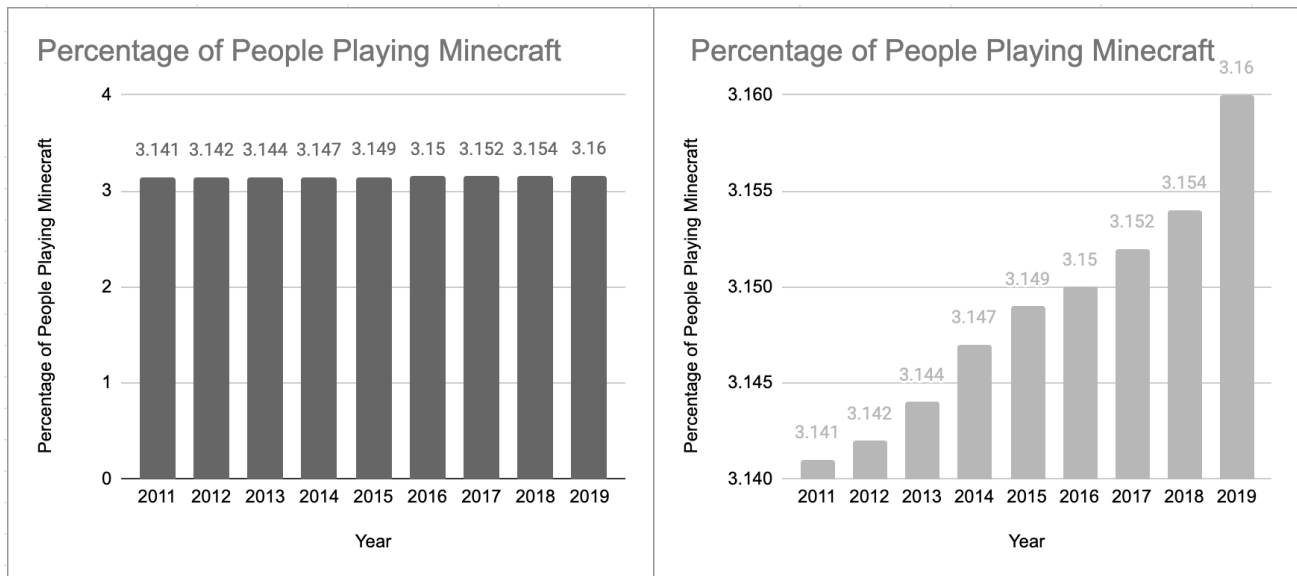
Part 5: Flexible Group Problems Carousel

Create flexible groups based on student understanding for this final section of the Action component of the lesson. Students will receive a set of data represented as a table and graph.
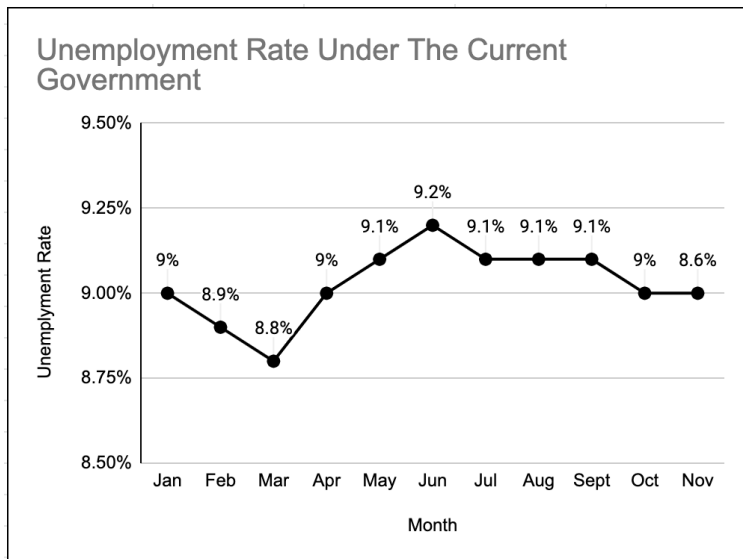
Have them answer the following:
1. What story is the graph trying to tell?
2. Is the graph misleading?
3. Why do they think the information on the misleading graph is shown in this way?
4. What changes would they make to improve the misleading graph?
5. Create a box plot.
6. What does the box plot reveal about the data?
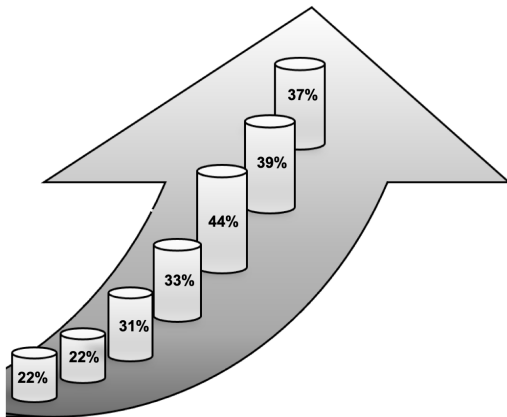7. Does the box plot tell a different story? Explain the story.

The Minecraft Story

Percentage of People Playing Minecraft

3.141 3.142 3.144 3.147 3.149 3.15 3.152 3.154 3.16

2011 2012 2013 2014 2015 2016 2017 2018 2019
Year

Percentage of People Playing Minecraft

3.16
3.154
3.152
3.15
3.149
3.147
3.144
3.142
3.141

2011 2012 2013 2014 2015 2016 2017 2018 2019
Year

The Unemployment Story

Unemployment Rate Under The Current Government

The Kit Kot Story: New Social Media Data

The data above illustrates the number of teenage users of the new social media service "Kit Kot" in the last 7 years

Consolidation (10-15 Minutes)

Consolidating this activity will involve an exit card (see Supplemental Resources for a printable exit card) with the following question:

Tell Me 5
"Tell me 5 things you learned about representing and analyzing data"

Would You Rather: Return to Opening Problem

Further consolidation will occur through a "Would You Rather" question. Share this data with the class and ask students to justify which player they would rather have on their team.

The table below displays the free throw % for the past 8 years of three basketball players.

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59	74	62
78	76	97
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98	72	45
63	71	85
72	83	72
93	82	68
79	84	99

Note: The mean, median and the mode are the same for each player

You could use the chart with the box plot below OR just the table.

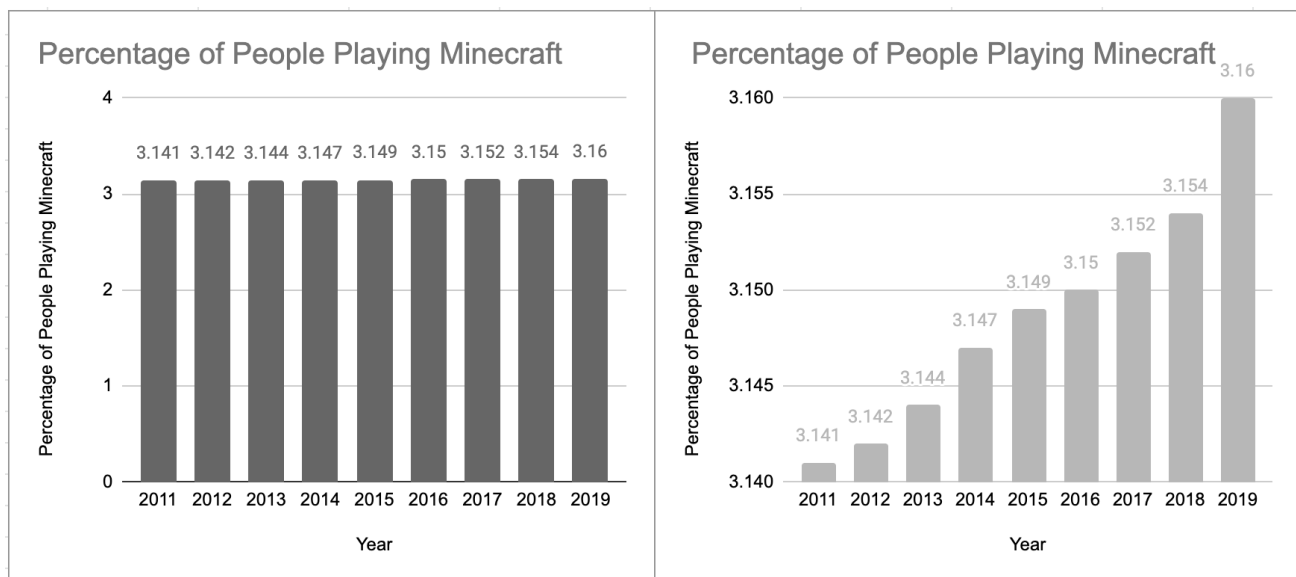# MTH1W.3 Supplemental Resources

Prior Knowledge:
Students enter should this activity with the following grade 8 expectations:
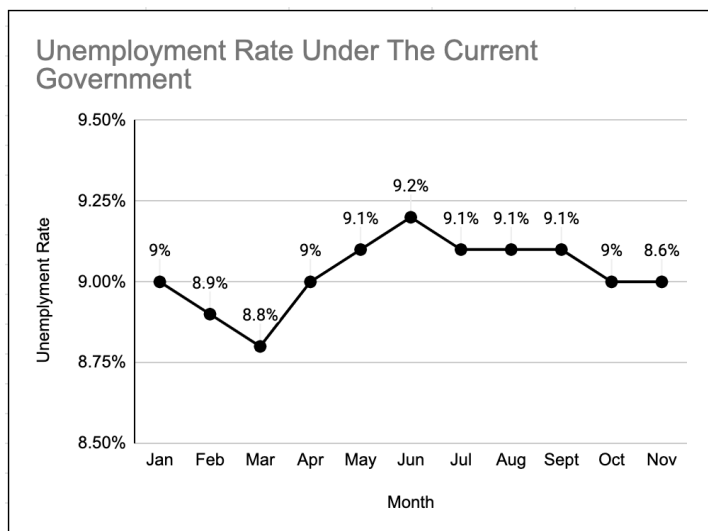**D. Data**
- D1.1 identify situations involving one-variable data and situations involving two-variable data, and explain when each type of data is needed
- D1.3 select from among a variety of graphs, including scatter plots, the type of graph best suited to represent various sets of data; display the data in the graphs with proper sources, titles, and labels, and appropriate scales; and justify their choice of graphs
- D1.6 analyse different sets of data presented in various ways, including in scatter plots and in misleading graphs, by asking and answering questions about the data, challenging preconceived notions, and drawing conclusions, then make convincing arguments and informed decisions
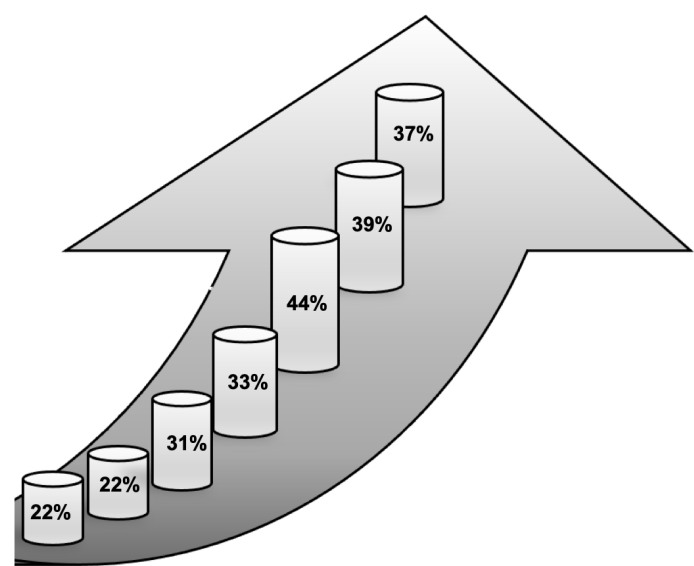
Flexible Group Problems Carousel
The Minecraft Story

The Unemployment Story

The Kit Kot Story

22%

22%

31%

33%

44%

39%

37%

Assessment Mapping

Lesson Section	Task	Assessment	Success Criteria
Minds-On Part 1	Video of Stephen Curry	Conversations and observations	
Minds-On Part 2	Data graphic of shots taken around the court	Conversations and observations	Checklist: ❏ analyse data and determine the story it is telling ❏ use data to make decisions about a real world context
Action Part 1	Revisiting percentages	Observations	
Action Part 2	Collecting data	Conversation and observations	Checklist: ❏ determine what data needs to be collected

Action Part 3	Organizing data/Gallery Walk	Conversation and observations, collection of evidence (ex. photos of student work) documenting student thinking	Checklist:
			❏ determine how to organize data in helpful ways
			❏ represent data
			    ❏ Histogram
			    ❏ Pie Graph
			    ❏ Organized Table
			❏ make connections between different representations

Action Part 4	Box plot direct instruction	Conversations and observations	Checklist: ❏ measures of central tendency ❏ arranging data
Action Part 5	Misleading data and box plots	Conversations and observations, collection of evidence (ex. photos of student work, shared electronic document) of student thinking and	Checklist: ❏ read data and use it to create a box plot ❏ interpret and explain the different components of a box plot

		understanding of the different components explored throughout the lesson	❏ determine when a graph/data is trying to mislead ❏ utilize box plots to explain more about real world situations
Consolidation	Exit card 5 things	Journal entry	May include some or all of the success criteria
Consolidation	Which One Would You Rather	Journal entry	May include some or all of the success criteria

Additional Resources

Other resources that may be of interest to teachers include:

PBS Lesson plan: How to teach your students about fake news
EdCan Network: How do we teach students to identify fake news?

Some useful fact checking website:
- Snopes
- FactsCan
- FactCheck
- HoaxSlayer

Washington Post: Using models to help understand the CoronaVirus

Exit Ticket: Representing Data and Box Plots

Name:

QUESTION: Tell me 5 things you learned about representing and analyzing data, use sketches to explain your thinking if that helps