Modelling the COVID-19 Outbreak in Canada

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Activity summary

This is a free resource for teachers and students, and is part of the Callysto project, a federally-funded initiative to bring data science skills into Grade 5-12 classrooms in Canada. .

In this activity, students will use an online Callysto notebook to explore:

- how to use mathematics to create a model of the COVID-19 outbreak;
- compares the model explored in this session against real data on the outbreak in Canada.

This activity can be done with students in person, or, online.

Grade level

This activity is best suited for Grades 9-12 students.

Learning outcomes

- Understanding of what a mathematical model is, and its uses.
- Understanding of the process to create a mathematical model.
- Problem solving.
- Critical thinking.
- Interpreting the results associated with a model and comparing those results against real data.

Ideal prior knowledge for students and teachers

1. Comfort with the notion of mathematical functions.
2. Comfort with reading and interpreting graphs.
3. Comfort with abstract thinking, looking beyond the information you see in front of you.

4. Familiarity with the word “rate” (a comparison of two related quantities). In this context the first quantity includes the number of infectious people and the second quantity is time.

Required materials

1. A charged computer.
2. Access to the internet.
3. An installed internet browser, preferably Google Chrome, Safari or Firefox.
4. A Google or an Outlook email account.

Preparation

1. **Facilitate a discussion with the students on the COVID-19 outbreak in Canada since it started.**

   Questions to help you guide the discussion include:

   a. How is the disease transmitted?(i.e. how do people get COVID-19?)
   b. What causes COVID-19?
   c. What role does social distancing play in the outbreak?
   d. What does it mean when we say “flattening the curve”?

   Refer to the following resources to help you guide your discussion:

   - The New York Times: What’s Going On In This Graph? https://www.nytimes.com/2020/09/10/learning/whats-going-on-in-this-graph-covid-19-cases-in-america.html
   - CTV News: Infographics, COVID-19 in Alberta by the numbers https://edmonton.ctvnews.ca/infographics-covid-19-in-alberta-by-the-numbers-1.4874153
   - YouTube Video: What are pathogens? https://www.youtube.com/watch?v=WsZS4RCWpcE
   - YouTube Video: How pandemics spread https://www.youtube.com/watch?v=UG8YbNbdaco

2. **Introduce the concept of mathematical modeling**

A mathematical model is a description of a system using mathematical concepts and mathematical language. You can think of a math model as a tool to help us describe what we believe about the workings of phenomena in the world. We use the language of mathematics to express our beliefs. We use mathematics (theoretical and numerical analysis) to evaluate the model, and get insights about the original phenomenon. You can use the table below to help with outlining steps followed in mathematical modelling.

Step	Description
1	**Choose what phenomenon you want to model**
2	**What assumptions are you making about the phenomenon**
3	**Use a flow diagram to help you determine the structure of your model**
4	**Choose equations**
5	**Implement equations using Python**
6	**Solve equations**
7	**Study the behaviour of the model**
8	**Test the model**
9	**Use the model**

3. **Ask the students to open this Jupyter notebook link, http://tinyurl.com/y5m8auk9, and follow the activities marked as "Student activity".**

Some of these activities include watching the following YouTube videos:

a. Tutorial part 1: Using mathematics to model the COVID-19 outbreak: https://youtu.be/LTPJQnEZOLE
b. Tutorial part 2: Exploring a COVID-19 math model using Python and Open Data https://youtu.be/wdRYoAOCs_k

Following the videos, the students are invited to identify the assumptions that the model makes. You can refer to the Teacher version of the notebook with notes on what those assumptions are in this link http://tinyurl.com/y3dwqkgq. Discuss with the students if they agree or disagree with these assumptions. If they disagree, how would this change the model?

4. **Discuss the simulation 1 exercise (found in the notebook) with students**

   The first simulation exercise involves changing the rate of contact (called “beta”).

   Suggested discussion questions:

   - How does increasing the rate of contact affect the number of infectious individuals?
   - Why do you think people have been asked to practice social distancing?

5. **Discuss the simulation 2 exercise (found in the notebook) with students**

   The second simulation exercise involves changing both the rate of contact (called “beta”) and the rate of death due COVID-19 (called “alpha”).

   Suggested discussion questions:

   - What trends do you see when you change the rate of contact and death rate?
   - How deadly is COVID-19 compared to outbreaks from other viruses in the coronavirus family, such as the MERS and SARS?.

6. **Let students test out the last two simulations**

   The last two simulations involve the remaining parameters in the model, with the last simulation incorporating real data on the number of COVID-19 confirmed cases. The students can then play with the remaining parameters until they find a combination of values that “fits best” the data.

7. **Discuss with the students the limitations of the model as well as the data.**
   Some of them are listed below:

   Limitations of the model:

   i. The model assumes a constant contact rate, whereas we have modified our contact rate by practicing social distancing and taking lockdown measures. The model assumes people will be immune to the virus after they recover, which is unproven.
   ii. The model doesn't take into account inner circles having higher probability of exposure and infection when a member is infectious.
   iii. The model doesn't account for other factors such as age, immunodeficiencies, and groups who might be more impacted than others.
   iv. The model is sensitive to perturbations - small changes in parameters lead to significant changes in number of people in Exposed and Infected categories.

   b. Data's limitations:
      i. Infected individuals are those who got tested and obtained a positive result - it does not take into account actual cases that were never reported.
      ii. Infected individuals present symptoms - difficult to measure asymptomatic transmission.
      iii. Data does not accurately represent whether a report is from the same individual at different times.
      iv. Data is based on test accuracy - a false negative means there might be infected people who tested negative, similar to a false positive, i.e. people who are not infected who test as if they were.

8. **Suggested student assignment**

   Ask students to submit a short essay (i.e. x-y words or x-y pages) on their understanding of what mathematical models are,how models were used in the context of COVID-19, and how COVID-19 compares to other outbreaks, like SARS and MERS.