Zombie Virus

Contributed by: Math on my Mind

Purpose: to discuss growth rates and mathematical modeling

Background

The study of population growth and interaction is used in studying biological ecosystems, conducting medical research, and regulating industries such as fishing. Knowing the key differences between basic growth models gives a deeper understanding of mathematical functions and environmental carrying capacities, and adds to general scientific literacy.

The growth of an infected population as a disease spreads is studied in public health. For instance, constructing an interaction network is potentially beneficial to aid in preventing the spread of sexually transmitted infections such as HIV/AIDS.

Overview

In a three-part activity, students will simulate various growths of a zombie population based on different infection scenarios. Approximate run time is 45-60 minutes.

Materials

- white/chalk board or document camera with projector
- class set of 6-sided dice
- interaction handout

Set Up

Draw a set of axes on the board labeled with days (x-axis) and zombie population (y-axis). These axes will be used to plot and compare the three zombie growth exercises.

Linear Growth

Humans stand on one side of the classroom with a single “alpha zombie” on the other. Each “day” the alpha zombie infects 2 humans, who move to the zombie side of the room. The total number of zombies each “day” should be plotted on the axes.

Note: In order to have a linear growth curve for the zombie population, it is important that only the alpha zombie infect "victims" in this part of the activity.

After the zombies infect all/most of the humans, discuss the linear growth of this model and ask students how this model might be improved to better simulate a real zombie outbreak. The typical response that motivates the exponential growth model is that "all zombies eat brains" so that the virus should spread faster when there are more zombies.

Exponential Growth

Humans stand on one side of the classroom with a single "alpha zombie" on the other. Each "day", *every* zombie (not just the alpha zombie) infects 2 humans each, who all move to the zombie side of the room. The total number of zombies each "day" should be plotted on the axes.

Note: In order to have an exponential growth curve for the zombie population, it is important that each day, every zombie infects 2 "victims" each day.

After the zombies infect all of the humans, discuss the exponential growth of this model. Note that the zombie population grows much faster when there are more zombies. Again, ask the students how this model might be improved to better simulate a real zombie outbreak. A typical response is that "zombies don't eat a set number of humans each day" or something about being able to survive the zombie apocalypse. A key discussion point is that whenever the zombie or human population is small, the zombie population should spread slower; the exponential model exhibits the first but not the second.

Logistic Growth

The final growth model is based on a dice-roll simulation. Each student receives a 6-sided die, a handout to track their interactions with other students (see attached), and a number. An interaction is either safe or risky based on the sum of the two dice rolls (2-4 is safe, 5-12 is risky). It is imperative that students accurately record their interactions. With younger groups, we typically do the interactions for Day #1 to make sure everyone understands how it is supposed to work.

To help ensure an accurate logistic growth in this simulation make sure students interact with as many different people as possible, and three different people each day.

After students complete all of their interactions and are reseated, we track the spread of the zombie virus from the previously unknown alpha zombie. The virus spreads to a human on a certain day if the human has had a risky encounter with a zombie during that day. Typically we write every student's number on the board and track the zombie population by crossing out numbers that are zombies. Between each day, count and plot the number of zombies.

Typically, the resulting plot very closely resembles logistic growth that saturates the classroom population or can be fudged when tracing the plot to resemble logistic growth. The logistic model exhibits the desired characteristics mentioned in the previous discussions.

Modifications and Extensions

This activity was originally implemented as the spread of the flu virus and was switched to zombies base on their recent popularity among students. Students are typically surprised when we tell them that mathematicians have equations that can predict the outcome of a zombie virus.

Depending on the level of the audience, explicit and general formulas for linear and exponential growth can be discussed.

Mathematical modeling can be discussed in terms of predator-prey interactions, which can be used to balance ecosystems (wolves in Yellowstone National Park and marine protected areas). Starting with a discussion of predator aggression (the different zombie growth rates), other factors such as birth rates and prey dependency (can predator eat something else) can be added as potential improvements to the predictive model. The Lotka-Volterra differential equations can potentially be discussed with an advanced group of high school students.

The spread of diseases can be described mathematically using the SIR model, which relates the sizes of susceptible, infected, and resistant populations. A notable feature of this mathematical model is that lowering the initial susceptible population drastically reduces the number of people who become infected. The impact of vaccinations under this model can be discussed.

The logistic growth model appears in ecology with carrying capacities, analysis of neural networks, tumor growth in medicine, to described the concentrations in chemical reactions, in linguistics to describe language change, and in economics to describe how innovation spreads.

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Some References

http://data.worldbank.org/indicator/SP.POP.GROW

Bohnsack, James A. "Marine reserves: they enhance fisheries, reduce conflicts, and protect resources."*Oceanus* 36.3 (1993): 63+. *Academic OneFile*. Web. 21 Oct. 2014.

http://www.nature.com/nature/journal/v423/n6940/full/423606a.html

http://www.livescience.com/38527-surviving-a-zombie-apocalypse-math.html

http://www.sims.scienceinstruction.org/predprey/

http://www.maa.org/publications/periodicals/loci/joma/the-sir-model-for-spread-of-disease-the-differential-equation-model

Attachments

Handout for tracking interactions

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Will the Zombie Virus Get You???

Zombies are coming to eat some brains!!!!

My Number Is: _____

Each time you talk to a friend, roll two dice and add them up:

5-12: RISKY ENCOUNTER!!! **2-4: You are Safe!!!**

Day #1	
Friend's Number	**Risky? (Yes/No)**

Day #2	
Friend's Number	**Risky? (Yes/No)**

Day #3	
Friend's Number	**Risky? (Yes/No)**

Day #4	
Friend's Number	**Risky? (Yes/No)**

Day #5	
Friend's Number	**Risky? (Yes/No)**

Day #6	
Friend's Number	**Risky? (Yes/No)**