The Traveling Virus

New Mexico
Supercomputing Challenge
Final Report
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Team 70
Navajo Preparatory School

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Executive Summary

Our project will be dealing with our school, Navajo Preparatory School. We plan to use the StarLogo computer model to test how fast a virus can spread from one student to another. The school is made up of residential students and day students. The residential students return on Sunday during a regular school week. The students come out from Kayenta, AZ to Albuquerque, NM and Gallup, NM. Day student travels each day from Bloomfield to Two Grey Hills daily. The data we have collected does not show whether or not it is the day student or the residential student who carries the infecting virus and spreads among the other students.

In the year 2003 the Navajo Preparatory School campus experienced an outbreak of the influenza virus. A doctor's recommendation would be for a student who has influenza (the flu) to be absent from school for two to three days. During the influenza outbreak students were missing more than two to three days of school. The nurse observed that the number of students missing school for more than three days because of the influenza virus was increasing, this lead to the cancellation of school. Our main focus is to answer the question: Was the cancellation of school for three days necessary to slow down the infection rate of the flu symptoms?

We began answering our question by collecting statistical information about the attendance record the week of November 17 to 21 of 2003. There was a large number of student who were absent on Monday of this week, as the week continued more and more students were sent home due to symptoms of influenza. The students were released on Thursday to go home to slow down the rate of the spreading flu virus. They were given three days to recover from the symptoms.

Hypothesis

The prediction is that it was not necessary to cancel school for three days due to the influenza virus.

Research

Influenza virus also known as the flu is a dangerous disease that is caused by influenza virus. It is different from a cold because the symptoms are more severe. The influenza viruses infect the respiratory area the nose, throat, and lungs. The symptoms include: fever, malaise, nasal congestion, cough, headache, sore throat, body aches, Tiredness, runny or stuffy nose, diarrhea and vomiting.

There are three types of Influenza viruses, A, B, and C. Viruses A and B cause an outbreak of a contagious disease that spreads rapidly and widely every winter. Receiving a flu shot can prevent illness from types A and B. Every year in the United States 10%-20% of the people are infected by this disease. Leading to an average of 36,000 people dead and 114,000 people hospitalize. Type C virus does not cause any epidemics, it causes mild illness. Receiving the flu shot can not prevent type C from occurring.

The virus is spread from person to person through respiratory droplets by sneezing and coughing. People become infected by touching something or someone that has virus droplets on it, then touching their mouths, eyes, and nose.

To protect yourself from the virus, you can receive a flu shot ever year. There are two types of flu shots given in the United States. There is the original flu shot, a vaccine that is given by a needle usually in the arm. Second, is the nasal-spray flu vaccine. The best time to receive your flu shot is in November or October. Early October is when the flu season can began and last until springtime.

Method

- Collected statistical information on the population of students at Navajo Preparatory school to find the year, month, and week the outbreak took place.
- Used the general reference equation for the spread of the virus
- Surveyed the students to determine how many have been sick and missed days of school during the fall semester of 2005
- Graphed the regression and rate of change for the data collected from the survey
- Used the computer program, Starlogo, to enter the data from the week of the outbreak as well as the data collected during fall semester of 2005.

Data

This is the week when the students were released due to the influenza virus.

Week of Outbreak
Total Enrollment: 199

Day	Number of Students Absent
November 17	8.5
November 18	19.5
November 19	22.5
November 20	28.5
November 21	Release

This is the data that was collected after surveying the students. Only one third of the students replied to the survey. This was not enough information but there was enough to make a logistic regression.

X= day
P (t) = number of people infected with virus (reference equation)
f (t) = number of students who have been infected with the virus (logistic regression)

X	P (t)	f (t)
0	4.74	0
1	11.92	0
2	26.89	0
3	50	5
4	73.11	14
5	88.08	22
6	95.26	32
7	98.20	44
8	99.33	58
9	99.75	64
10	99.91	75
11	99.97	86
12	99.99	92
13	100	98
14	100	100
15	100	102

Math Model

Reference Equation:

$P(t) = 100 / (1+e^{3-t})$

- $P(t)$ = total number of people infected with the virus
- t = time in days
- e = natural number (exponential growth)

Average rate of change:

$$P(t) = 100e^{3-t} / (1+e^{3-t})^{2}$$

This equation is a typical logistic function for the spread of the virus symptoms.

Spread of the flu symptoms

Logistic Regression:

$$f(t) = \frac{116.6}{(1+21.692e^{-0.417x})} - 9.640$$

- $f(t)$ = number of infected students
- x = time in days
- e = natural number (exponential growth)

Average Rate of Change:

$$f'(t) = \frac{1054.713e^{-0.417x}}{(1+21.692e^{-0.417x})^{2}}$$

Conclusion

Working on this project was interesting and a lot of fun. We had many difficult obstacles in our path to make our project a success, but overcame them together.

Collecting our statistical information was complicated because we only knew the year the outbreak took place. In addition to that, running our data in StarLogo was stressful and frustrating, because the program was not performing the tasks we wanted it to do. Eventually we had our program running great.

After running our program several times and graphing our equations, we found out that the number of flu cases, symptoms, and the average rate of change were increasing rapidly. As a result, the nurse decided to cancel school which was a good decision. These results dismiss the hypothesis that states it was not necessary to close school due to the influenza virus.

Acknowledgements

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Reference

Finney, Ross L., Demana, Franklin D., Waits, Bert K., Kennedy, Daniel. Calculus: Graphical, Numerical, Algebraic. New York: Addison Wesley Longman, Inc. 1999.

Health Matters: Flu. National Institutions of Health: U.S. Department of Health and Human Services. January 17, 2006 . February 16, 2006 <http://www.niaid.nih.gov/factsheets/flu.htm>.

Influenza (Flu). Department of Health and Human Services: Centers for Disease Control and Prevention. November 5, 2005. November 12, 2005 <http://www.cdc.gov/flu/>.

Influenza. Illinois Department of Public Health. November 12, 2005 <http://www.idph.state.il.us/flu/fluhome.htm>.

Kane, Connie. Personal Interview. 6 Dec. 2005.

School Health Issues: Flu Seasons and School. The Center for Health and Health Care in Schools. September 14, 2005 . November 12, 2005 <http://www/healthinschools.org/sh/influenza.asp>.

Appendix A

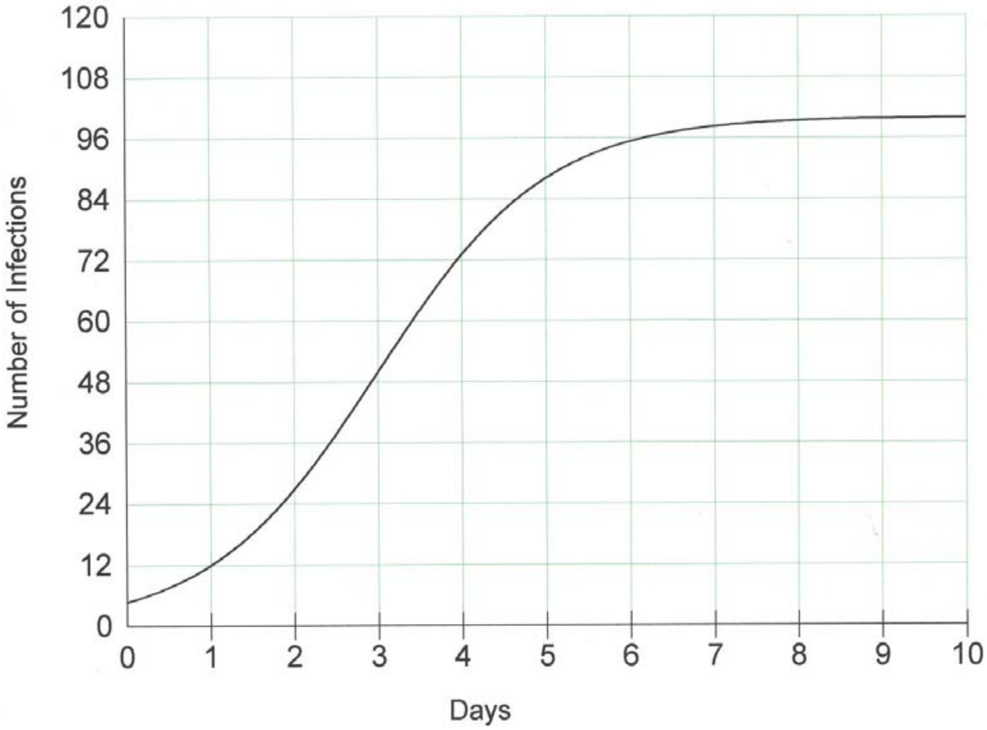
A Typical Logistic Function for the Spread of a Virus
Graph: Reference Equation

The Spread of Viral Flu Symptoms
Graph: Logistic Regression

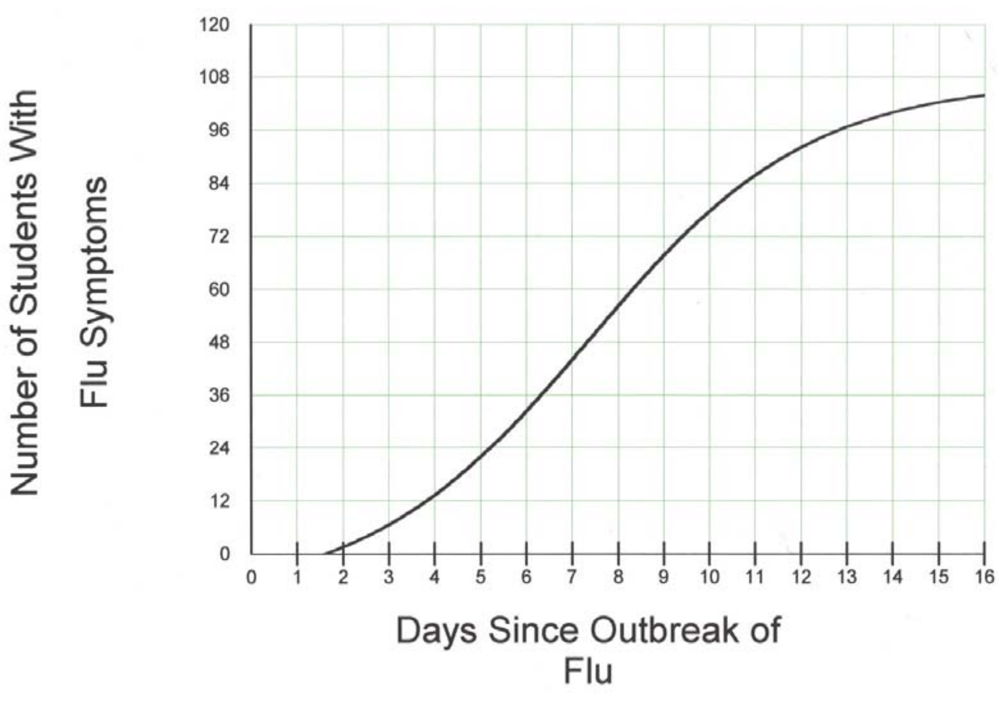
Rate of Change in New Flu Cases
Graph: Average Rate of Change of the Logistic Regression

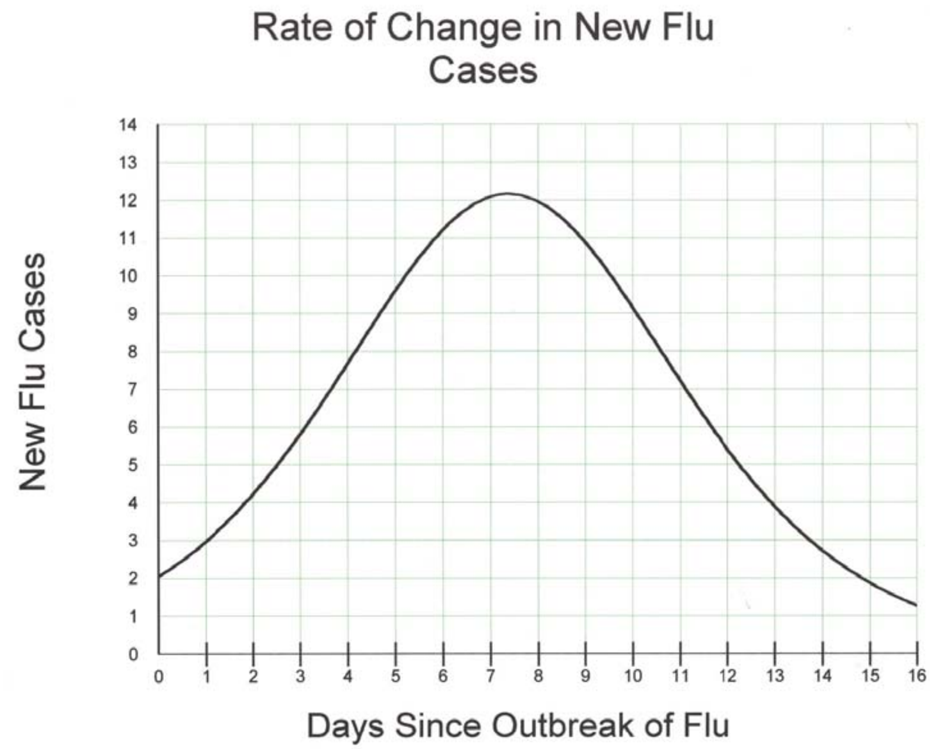
Spread of the Virus of Campus
Graph: StarLogo Computer Program

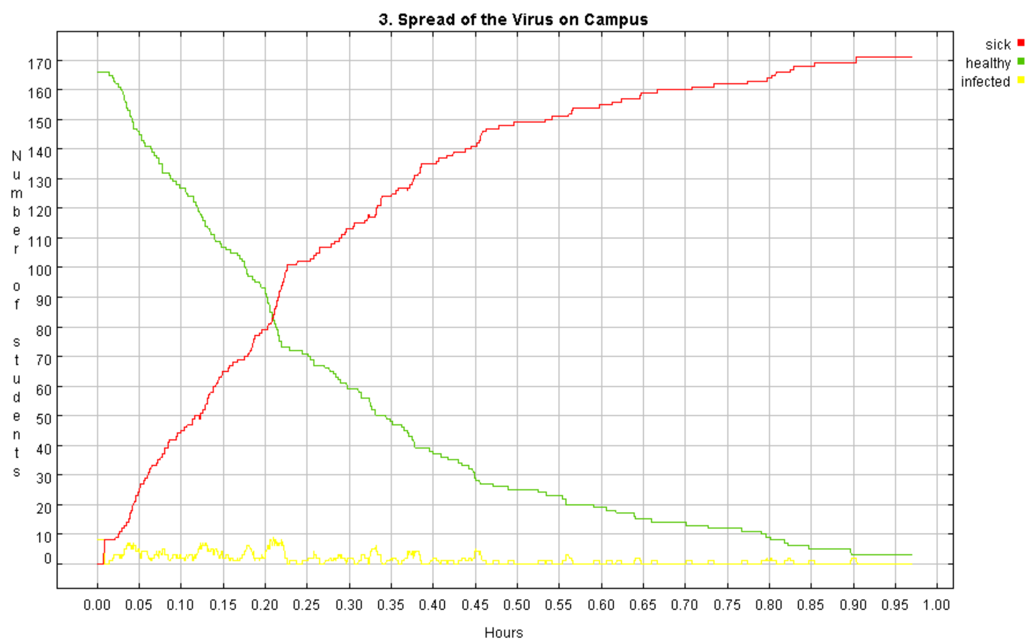
A Typical Logistic Function For the Spread of a Virus



THE SPREAD OF VIRAL
FLU SYMTOMS







inti-infected 5
recovery rate 5

Information that was found when we researched the number of students who are infected with the flu viral symptoms.

Appendix B

Turtle Procedures

```
turtles-own [sick? days-infected days-sick]

to infect
  if color = red                   ;if you're sick, make all the other turtles on your patch sick
    [ go-to-nurse
      sneeze
     set days-sick days-sick + 1
     if days-sick > 125
     [setxy 1 6]
     if pc-ahead = purple [setxy ((random 21) - 0) ((random 13) - 0) ]
     if pc = white [bk 2 rt 180]
    ]

  if color = yellow
    [  rt random 100
       lt random 100
       fd 1
      set days-infected days-infected + 1
      if days-infected > 100 [ setc red set days-sick 0 ]
      if pc = red [bk 1 rt 180]  ; here we are checking to see if we hit the wall, if so, step back and
turn around
      if pc = purple [bk 1 rt 180]
   ]

  if color = green
  [ rt random 100
       lt random 100
       fd 1
       if pc = red [bk 1 rt 180]  ; here we are checking to see if we hit the wall, if so, step back and
turn around
       if pc = purple [bk 1 rt 180]
   ]

end

to sneeze
  if (color-towards -30 1) = green [setc-towards -30 1 yellow set days-infected 0]
  if (color-towards 0 1) = green [setc-towards 0 1 yellow set days-infected 0]
  if (color-towards 30 1) = green [setc-towards 30 1 yellow set days-infected 0]
end

to go-to-nurse
```

```
  setxy 1 6
end

to make-healthy
  setc green
end
```

Observer Procedures

```
to setup
  ct
  crt 174
  ask-turtles
    [setxy ((random 41) - 41) ((random 61) - 30)
     setshape 2
     ifelse who < init-infected
       [setc yellow set days-infected 0
       setsick? true]
       [make-healthy
       setsick? false]]
  clearplots
end

to go
  startinfectbutton
end

to stop-it
  stopinfectbutton
end

to infected-%
  output ((count-turtles-with [sick?]) / count-turtles) * 100
end
```

Information

We used the Epidemic model that was already completed. We were able to make changes to fit the student populations and the change of infection rate.

This project presents a very simple model for the spread of a disease. There are two types of creatures: healthy creatures (green) and sick creatures (red). When a healthy creature comes in contact with a sick creature, it becomes sick.

Click the "setup" button to setup the creatures. Click the "go" button to start the simulation. The "infected-%" monitor shows the percentage of sick creatures. The "number" slider controls the number of creatures. (Changes in this slider do not take effect until the next setup.) The "init-infected" slider controls the initial number of sick creatures. The "recover-rate" slider controls the rate at which sick creatures become healthy.

If you start with just one sick creature, the disease spreads slowly at first. But as more creatures become infected, the disease spreads rapidly. The spread of the disease is a good example of exponential growth.

If the "recover" slider is set at greater than zero, sick creatures have a chance to become healthy again. So there are two competing forces: disease spreads by contact, but sick creatures have a probabilistic chance to become healthy again. Over time, the overall percentage of sick creatures should reach a rough equilibrium.

How do changes in the recover rate affect the equilibrium percentage of infected creatures? How is the equilibrium affected by changes in the total number of creatures?