

# The Love Bug virus

## Level

Upper secondary

## Mathematical Ideas

Exponential functions, modelling real data

## Description and Rationale

The recent havoc wreaked in cyber-world by the infamous Love Bug (computer virus) has served as the inspiration for the following technology-based activity. It involves a simulation of students exchanging e-mail messages, in order to investigate the spread of a computer virus if one “computer” is initially infected. The task is designed to illustrate a real-world instance of exponential growth, a topic that is usually found in senior secondary mathematics courses. Students should be encouraged to comment on the appropriateness of the exponential model and design further experiments that more closely match the process of sending, opening, and replying to e-mails.

## Resources

A Styrofoam cup for each student

Red Litmus Paper

Class set of graphics calculators and overhead projector unit or VI video link

2M NaOH (sodium hydroxide) solution (see the science technician about access to an appropriately concentrated sample of sodium hydroxide)

## The Activity

1. Before the lesson, half fill one cup with the NaOH solution and half fill the rest of the cups with water.
2. Distribute the cups randomly to each student when the lesson begins.
3. In pairs, the students should “exchange e-mail messages” with each other. That is, one student pours his/her liquid into the other student’s cup (sends a message) and then the second student pours half the mixed liquid back into the first student’s cup (replies to the message).
4. Students are to then line up for their ‘virus check’. That is, the teacher tests each student’s cup with the red litmus paper for the presence of base (NaOH) and results are recorded in the following table. (A data logger with pH probe can be used, if available, to check for the presence of the ‘virus’. However, the litmus paper colour change offers greater visual impact.)

<i>Number of E-mail Exchanges</i>	<i>Number of Computers Infected</i>
0	1

Note: Initially, there is only one computer infected.

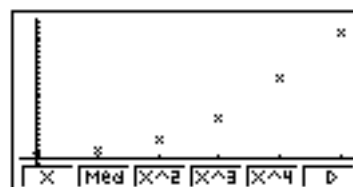
5. The students are to exchange another ‘e-mail message’ with a different person and repeat steps 3 and 4.

6. Repeat step 5 until all the students' computers in the class are infected with the virus, that is, the base (NaOH) is present in all the students' cups.

The following is a typical set of data for this activity, based on a class size of 25 students.

No. of e-mail exchanges	No. of computers infected
0	1
1	2
2	4
3	8
4	16
5	25

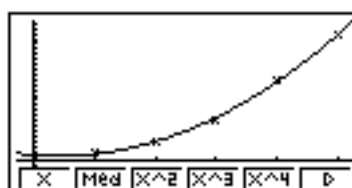
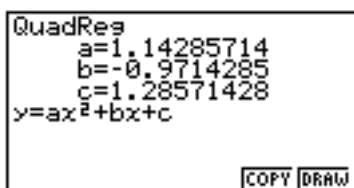
The data is placed into the lists via the STAT mode. A scatterplot is defined and drawn via the GRPH(F1) and SET(F6) commands.



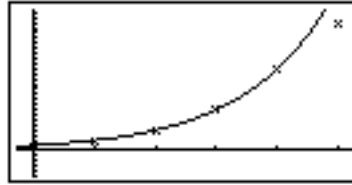
There are a number of possible models, these include: quadratic  
exponential  
logistic

Each of these models produces a satisfactory model over the range of the data collected, however the long term viability of such an approach need to be considered individually.

The quadratic model, determined here by the regression command, is shown below. While it fits the data well over the range of the data the nature of the squaring is that the growth in infection would not match the rapid spreading of the disease.



The exponential model would be expected to be of the form  $y = 2^x$ , provided there was not a significant number of cases where infected computers were communicating. This is reasonable when the number of infections is much less than the number of computers. As the number of infections increases and approaches the number of computers in the system the less effective will be the model.

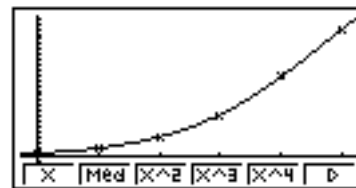


A more appropriate model in this case may be a logistic function. It shows the rapid growth in infections early on in the process along with the slowing down as the number of infections increases and the situation where infected computers have more exchanges with other infected computers occurs. The exact details of such a model are not best explored in this situation.

```

LogisticReg
a=56.4701902
b=0.85774008
c=44.4855485
y=c/(1+a*e^(-bx))
    
```

COPY DRAW



Assuming the exponential model students could be asked to make predictions and answer a number of questions.

A question such as “How many e-mail exchanges would need to occur in order to infect 100 computers with the virus? 1000 computers with the virus?” can best be answered using the TABLE function capabilities. The rule is placed in the table command and the range is set to give an appropriate amount of data.

The 100<sup>th</sup> infection occurs during the 7<sup>th</sup> exchange, while the 1000<sup>th</sup> exchange occurs during the 10<sup>th</sup> exchange.

```

Table Func :Y=
V1 2^X
V2:
V3:
V4:
V5:
V6:
[SEL DEL TYPE COLR RANG TABEL
    
```

```

Table Range
X
Start:0
End :10
Pitch:1
    
```

X	Y1
7	128
8	256
9	512
10	1024

10.0000  
FORM DEL ROW G-COM G-PLT

Students could be asked to predict the number of computers infected after 20 e-mail exchanges. This can easily be calculated in the RUN mode.

```

2^20
1048576.000
    
```

One of the areas where students need to improve is in the communication of mathematics. This ranges from explaining the approach and solution to a task to discussing the key issues in the construction and completion of a modelling activity. Students could be asked to consider the effect of class size on the determination of the model, and could lead to discussion of the effectiveness of the simulation in obtaining a model for the real-life situation.

A more general discussion on identifying limitations of models in the light of the real world context may follow. One major consideration revolves around do people always reply to e-mail messages, especially those from unknown senders. If not then a rethinking of our simulation model is necessary.

This activity is adapted from a similar task that provides a demonstration of the transmission of the AIDS virus (Legere & Stringer). For the original task the mixing of water and NaOH provided a realistic simulation of the exchange of body fluids through which the AIDS virus is transmitted. However, the spread of computer viruses is a little different, since the “exchange” of e-mail messages can be clearly separated into “sending” and “receiving”. In the present activity this difficulty is avoided by having students both “send” and “reply” to messages, thus allowing an already infected receiver to pass the virus to the sender in their reply. Students should be encouraged to evaluate the appropriateness of the exponential model in these circumstances, and to suggest how the simulation might be modified to more closely match the behaviour of e-mail users (e.g. not opening or replying to an infected message can be represented by not pouring half the mixed liquid back into the first student’s cup). This activity is quite open-ended, and has the potential to be used in a number of different classroom situations. The following list outlines some possible modifications and extensions in addition to that mentioned above:

- The activity could be used as an assessment task, with data collection done in class.
- Investigate the data obtained if two different viruses are spreading simultaneously.
- Investigate the effect on data if one or more student/s are in possession of a “virus scanner”, i.e. a piece of litmus paper used to test **before** “receiving an e-mail”.
- Investigate ways of altering the rate at which the virus spreads. Students could discuss this from various viewpoints e.g. creators of the virus versus a company who lost billions of dollars from its effects.

## **Reference**

Legere, C. & Stringer, C. AIDS transmission demonstration.