Spread Pattern of Infectious Diseases
Ramón L Torres

Purpose
The purpose of this activity is to introduce students to the spread of infectious diseases, and the prevention and control thereof. This activity lays a foundation for future lessons regarding microscopic life that focus on infectious diseases. The activity is also geared towards familiarizing students with the use of simulations to model complex real life events, in this case, using NetLogo to model the spread of an infectious disease.

Overview
This lesson is an adaptation of Activity #30: It's Catching from the class textbook Sciences & Life Issues, and it is meant to replace said activity.

Summary
Students discuss key vocabulary and concepts related to the spread of infectious diseases. They predict how they think an infectious disease would spread in a population. They use a computer simulation in NetLogo on the spread of an infectious disease to discover how fast diseases spread under different circumstances. The results are used to discuss the propagation of diseases, and to devise measures to control and prevent the spread of infectious diseases.

Key Vocabulary
The students will discuss the term infectious, which is central to the activity and the following lessons in the unit. They will also review the terms evidence, and trade-offs, which are relevant to scientific studies, as well as this activity.

Concepts and Skills
1. Graphs can reveal patterns that not apparent from data tables.
2. Models provide researchers a way to understand and communicate scientific information.
3. Diseases can be caused by infectious agents, genes, environmental factors, lifestyle, or a combination of these causes.
4. Infectious diseases can spread fast through the population.
5. Data can be analyzed to determine trends and/or patterns. Analyzing trends in how disease spreads can suggest ways of preventing its further spread.

CT-STEM Skills
Throughout the lesson, students will make use of several CT-STEM skills. Students will: (i.) collect/generate, analyze, and visualize data. (ii.) Assess a model, and use the model to identify/test solutions. (iii.) Use a model to understand causal relationships within a system.
Student Outcomes
At the end of the lesson, students will be able to:
1. Explain what are infectious diseases, and mention several possible causes.
2. Explain the difference between infectious and non-infectious diseases.
3. Identify factors that affect the propagation of infectious diseases.
4. Design an experiment to test the effects of several factors in the spread pattern of an infectious disease.
5. Use and manipulate a (NetLogo) model’s input (initial conditions), to run a simulation of a real life phenomenon.
6. Analyze observations and data generated from the simulation to produce findings regarding the spread of an infectious disease, which may support or refute an inquiry hypothesis.
7. Interpret and represent analysis results to produce findings, i.e., identify trends in the resulting graph representing the spread of an infectious disease.
8. Explain the spread pattern of an infectious disease.
9. Understand that while models are useful to simulate real life situations (i.e., the spread of an infectious disease), they are limited in scope, given their assumptions with regards to real world phenomena.

Time
The lesson should take two 40-50 minute class periods. Sections that have students with special needs might need extra time to complete the activity.

Level
This lesson is intended for middle school science (6th-7th grade level).

Materials and Tools

For each pair of students
1 Computer (with NetLogo, available from http://ccl.northwestern.edu/netlogo/)

For each student
1 Student worksheet
1 Sheet of graph paper (as needed)

Preparation
Before the lesson:
• Become acquainted with the model, and tailor the model details as needed.desired.

Day of the lesson:
• Set up computers in the student stations and with the pre-set program.
• Make the enough copies of the student worksheet to distribute to students.

Prerequisites
None.
Background

Causes of Disease

Diseases are caused by different factors. Some diseases are passed on from parent to offspring via genetic material. Other diseases might be transmitted among individuals via the exchange of germs through physical contact, and some other diseases can result from the environment, or contact with radiation. Diseases caused by infectious agents are considered to be infectious when they can be transmitted from one person to another, whether it is directly or indirectly.

Table 1: Examples of diseases caused by different factors. (Source: Science and Life Issues, 2001)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genes</td>
<td>cystic fibrosis, sickle cell anemia, hemophilia, childhood diabetes</td>
</tr>
<tr>
<td>Infectious Agents (Germs)</td>
<td>Colds, flu, pinkeye, food poisoning, malaria, plague, chicken pox, Ebola, AIDS, leprosy, polio, sexually transmitted diseases (e.g., syphilis, chlamydia)</td>
</tr>
<tr>
<td>Environment</td>
<td>radiation sickness, leukemia associated with radiation exposure, poisoning</td>
</tr>
<tr>
<td>Lifestyle</td>
<td>certain forms of cancer (e.g., lung cancer from smoking)</td>
</tr>
<tr>
<td>Combination of factors</td>
<td>asthma, certain forms of cancer, heart disease, adult onset diabetes</td>
</tr>
</tbody>
</table>

Spread of Infectious Diseases

Diseases spread slowly at the beginning; they start propagating faster and faster as more and more people get infected, and so this results in an exponential increase in the number of infected individuals in the population until everyone that could get infected, becomes infected. Tests in closed populations—a population that has no contact with other populations—show that number of infected people over time shows a bell-shaped curve. This is because people get infected increasingly fast, and then it reaches a point where everyone is infected, followed by recovery from the disease (sometimes immunization occurs from the disease), or death of the population.

The speed of spread depends in several factors: (i.) some diseases are more infectious than others, i.e., they spread easier, usually dependent on the means of transmission. (ii.) The number of susceptible people in the population, more specifically, the density of the population and the frequency with which susceptible people interact. (iii.) The behavior of people susceptible to infection, e.g., hygiene, risky behavior. Also, the total number of people infected will depend upon the number of people that are susceptible to getting infected, i.e., in some cases, vaccination and previous exposure to an infectious disease will make a person less susceptible to becoming infected.

Teaching Notes

Task #1: Have the class discuss the meaning of the term infectious.

The class begins by discussing what is an infectious disease and what causes infectious diseases. Following an inquiry approach, a suggestion is to open the floor by asking: *What are different ways in which diseases are caused?* After the participation of several students, have the discussion geared towards discussing the causes of diseases. The discussion should progress into the introduction of the term infectious.

In defining infectious, students will likely say that these can be transmitted from one person to another. Point out that infectious diseases can be transmitted *directly or indirectly*. In term of directly transmitted diseases, scientists consider diseases transmitted by other organisms to be infectious, and thus it is not only transmission from person to person. In terms of indirectly transmitted diseases, there are other means to catch a disease that does not need direct contact with another organism, e.g., spores in the air, germs on a surface.

It should be pointed out that not all diseases (Table 1) are infectious. For example, many types of cardiovascular disease could be developed from lifestyle, i.e., fitness and dietary choices, and a predisposition for heart disease can also be inherited through genes. However, many types of cardiovascular disease cannot be directly or indirectly transmitted, and hence they would not be considered an infectious disease. Diabetes is another good example, and so is skin cancer, since it is due to exposure to sun radiation.

Let the students know that they will be simulating the propagation of an infectious disease using a computer program. The model will have several input variables to simulate several different scenarios and they will then make conclusions based on observations.

Task #2: Have the class predict how an infectious disease might spread over time.

The purpose now is to have the students predict how the number of people infected with the disease will change over time. First, have the students (with their partners) discuss factors that might affect the rate of propagation of an infectious disease, followed by a class discussion. A suggestion for a starter question would be: *How quickly could an infectious disease spread and what factors might affect the rate at which it spreads?* There are several factors mentioned in the Background section.

Have the students predict how the number of infected people changes over time. Have students draw a graph of how they think this would look like. Let them know that the horizontal axis represents time, and that the vertical axis represents the number of people infected. Go around the classroom and observe what the students are coming up with and discuss their hypothesis with them. As a group discussion, ask the students to share their hypotheses with the class, and lead a discussion. Tell them that the objective of the experiment is to collect information that will allow them to answer the issue.
Task #3: Doing the activity.

You should be familiar with the NetLogo model by now. You should have also reviewed the model and made any adjustments if necessary. The model to be used in this lesson is a variation of the Disease Solo model included in NetLogo’s model library. There are several differences between the original version and the version used for this lesson, see the note below.

The model to be used in this lesson is a variation of the Disease Solo model included in NetLogo’s model library. There are several major differences:

- **User android**: The original model has an android that represents the user. The student is able to move the android around, but this can remove randomness in the system dynamics, and hence it is removed for this lesson.
- **Layout**: The layout of the original model contains buttons to operate the user android, and these buttons were removed. Also several buttons were moved around for aesthetic purposes.

NOTE

Hand out the student sheet for the lesson, and quickly go over how to use the model and the NetLogo environment. Make sure that the students have opened the correct model and that they are able to run it. Explain to the students that the model they will be using will only simulate the propagation of a disease with no possibility of recovery.

The students will design their own experiments to test the four variables: number of people in the population, chance of infection, and the two behavior variables, chase and avoid. Go around the classroom and observe the students, provide guidance if needed.

- **Number of people**: This will model the density of the population. The space in the model is limited, so increasing the number of people will alter the density of the population.
- **Chance of infection**: This will model the level of infectiousness of the disease. How likely is it that I will get infected if I get in contact with an infected person?
- **Chase**: This will model people that act like zombies, i.e., that knowingly want to make other people sick, or people that are careless with their behavior when they are sick.
- **Avoid**: This will model people that practice safe behavior, i.e., avoid sick people.

Task #4: Discuss the results and assess the model.

Have the students discuss the results with their partners, and then lead a discussion with the entire class. The students should all have similar results, i.e., the disease propagates exponentially. Have them discuss the relationship between the four variables (i.e., number of people in the population, chance of infection, chase and avoid).

Make the class think of ideas of how the model is successful (or fails) to model the spread of a disease in the population. Try asking: *How could we make the model better represent the spread of an infectious disease in real life?* Have the students discuss the question with their lab partners, and then have them share their ideas with the entire class. It would be useful to mention the fact that, in real life, people could recover from some types of infectious diseases, which would lead to a drop in the number of
infected people in the population over time, and to the “bell-shaped” curve mentioned in the Background section. This could be modeled with NetLogo by including a cure function.

**Task #5: Have them apply the results and observations to real life.**

Now have the students use their new knowledge on the propagation of infectious diseases to think about their day-to-day life. Make them think of flu-season, and ask them to think about how the disease would spread over time. Tell them to think that one student in the classroom is sick and ask them: *What do you predict will happen to the number of students infected with the flu over time? How many people will be infected within the day? Week? Month?* The number of students infected will increase over time until it flattens out, and then decreases as people recover from the flu. Then ask them: *Will everyone in the classroom catch the flu?* Not all students will necessarily get sick, however, in the model everyone gets infected, and this is a limitation of the model.

**Task #6: Have the students complete the analysis questions in the worksheet.**

Depending on time constraints, this can be assigned as homework.
Assessment

Following is a list of each outcome, and the suggested ways of assessment. Outcomes will be assessed using:

- Feedback from class discussions
- Feedback from one-on-one discussions while circling the classroom as the students work
- Worksheet responses (WQ’s, where WQ-1 stands for worksheet question 1)
- Analysis questions from textbook (AQ’s, where AQ-1 stands for analysis question 1)

Assessment by outcome:

1. Explain what are infectious diseases, and mention several possible causes.
   a. In-class discussion
   b. WQ-1, WQ-2

2. Explain the difference between infectious and non-infectious diseases.
   a. In-class discussion
   b. WQ-1

3. Identify factors that affect the propagation of infectious diseases.
   a. In-class discussion

4. Design an experiment to test the effects of several factors in the spread pattern of an infectious disease.
   a. One-on-one discussions
   b. Experimental Design (Modeling Task #2), WQ-6

5. Use and manipulate a (NetLogo) model’s input (initial conditions), to run a simulation of a real life phenomenon.
   a. One-on-one discussions
   b. Experimental Design (Modeling Task #2), WQ-7

6. Analyze observations and data generated from the simulation to produce findings regarding the spread of an infectious disease, which may support or refute an inquiry hypothesis.
   a. WQ-4, WQ-5, WQ-7

7. Interpret and represent analysis results to produce findings, i.e., identify trends in the resulting graph representing the spread of an infectious disease.
   a. In-class discussion
   b. WQ-4, WQ-5, AQ-1, AQ-3

8. Explain the spread pattern of an infectious disease.
   a. In-class discussion
   b. WQ-4, AQ-1

9. Understand that while models are useful to simulate real life situations (i.e., the spread of an infectious disease), they are limited in scope, given their assumptions with regards to real world phenomena.
   a. In-class discussion
   b. AQ-4, AQ-5
Experimental Design Assessment

An experimental design will answer yes to all of the following three questions.

- **Yes**  **No**
  Does the experiment studies one variable at a time?
  *The experiment must treat each variable separately, while the other variables are held constant, so that it can actually provide a description of the effect of the variable under study.*

-  **No**  **Yes**
  Does it consider several values of each variable (where applicable)?
  *The variables “number of people” and “chance of infection” must be considered at different levels, to be able to determine whether there are trends associated with these two variables. At least three to five different values for each variable should be considered.*

-  **Yes**  **No**
  Does it consider several trials of each run?
  *The model is stochastic in nature, and so the same results will not be reproduced in a second run. Ideally, for each instance, students will run the model about ten times. Due to time constraints, and the level of education, three runs should suffice.*

Additional Information