Get Connected!

Subject: Mathematics

Grade Level: *part I*: 6 – 7; *part II*: 8 – 9

Rationale or Purpose: This activity explores a real-world scenario based on mathematical modeling techniques of disease spread.

Materials:
- Pencils and paper
- Scissors for cutting out polygons
- String to act links that connect nodes
- Plenty of desk or floor space to interconnect the networks

Lesson Duration: 30 minutes; additional discussions of disease spread, types of diseases, and other types of networks (Internet, food web, air transportation) are encouraged.

Objectives:

6th Grade Math 111.22
(2C) use multiplication and division of whole numbers to solve problems including situations involving equivalent ratios and rates
(3A) use ratios to describe proportional situations
(3B) represent ratios and percents with concrete models, fractions, and decimals; and
(3C) use ratios to make predictions in proportional situations.
select and use appropriate units, tools
(6D) convert measures within the same measurement system (customary and metric) based on relationships between units.
(10C) sketch circle graphs to display data
(11A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics
(12A) communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models
(12B) evaluate the effectiveness of different representations to communicate ideas

7th Grade Math 111.23
(1B) convert between fractions, decimals, whole numbers, and percents mentally, on paper, or with a calculator
(2A) represent multiplication and division situations involving fractions and decimals with concrete models, pictures, words, and numbers
(3A) estimate and find solutions to application problems involving percent
(3B) estimate and find solutions to application problems involving proportional relationships such as similarity, scaling, unit costs, and related measurement units
(13A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics
(14A) communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models

8th Grade Math 111.24
(1B) select and use appropriate forms of rational numbers to solve real-life problems including those involving proportional relationships
(2A) select and use appropriate operations to solve problems and justify the selections
(2C) evaluate a solution for reasonableness

(3B) estimate and find solutions to application problems involving percents and proportional relationships such as similarity and rates
(5A) estimate, find, and justify solutions to application problems using appropriate tables, graphs, and algebraic equations
(11B) use theoretical probabilities and experimental results to make predictions and decisions;
(11C) select and use different models to simulate an event.
(12C) construct circle graphs,
(13A) evaluate methods of sampling to determine validity of an inference made from a set of data
(13B) recognize misuses of graphical or numerical information and evaluate predictions and conclusions based on data analysis
(14A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;
(14B) use a problem-solving model that incorporate understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;
(14C) select or develop an appropriate problem-solving strategy from a variety of different types, including drawing a picture, looking for a pattern, systematic guessing and checking, acting it out, making a table, working a simpler problem, or working backwards to solve a problem; and
(14D) select tools such as real objects, manipulatives, paper/pencil, and technology or techniques such as mental math, estimation, and number sense to solve problems.
(15A) communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models; and
(15B) evaluate the effectiveness of different representations to communicate ideas.
(16A) make conjectures from patterns or sets of examples and nonexamples;
(16B) validate his/her conclusions using mathematical properties and relationships.

Background Information and Tasks:

Part I

1. **Building Your Own Disease Network**

Networks that consider variation in behavior are a new approach to modeling the spread of infectious diseases. The first step in modeling is to build a realistic contact network, that is, to quantify the patterns of interactions that actually take place in the real world.[1]

Epidemiology is the study of the patterns, causes and control of disease in groups of people, and **epidemiologists** are the people who do it. Epidemiologists are interested in predicting and controlling the spread of disease on many different scales from the entire globe, to a single country like the US, to a state, large metropolitan area, or smaller community. They may be interested in disease transmission within single facilities like hospitals, nursing homes, schools, military compounds, cruise ships, etc.[1]

The first step is to create many households based on the size of the city and the reported distribution of household sizes. Epidemiologists then give each person in a household an age, based on census data. They assume that any two people in the same household will have opportunities to spread disease to one another, and so they connect all individuals in the same household, forming completely

[1] Dr. Lauren A. Meyers, presentation of the University of Texas Environmental Science Institute’s *Hot Science – Cool Talks* Outreach Lecture Series (Vol. 42), April 2006.

connected sub-networks. Then they assign individuals (kids and teachers) to schools based on school districting information. To connect individuals at the same school directly to each other, epidemiologists first break them into classrooms according to classroom size estimates. They then connect them to one another at higher rates if they are in the same classroom than if they are in different classrooms.[1]

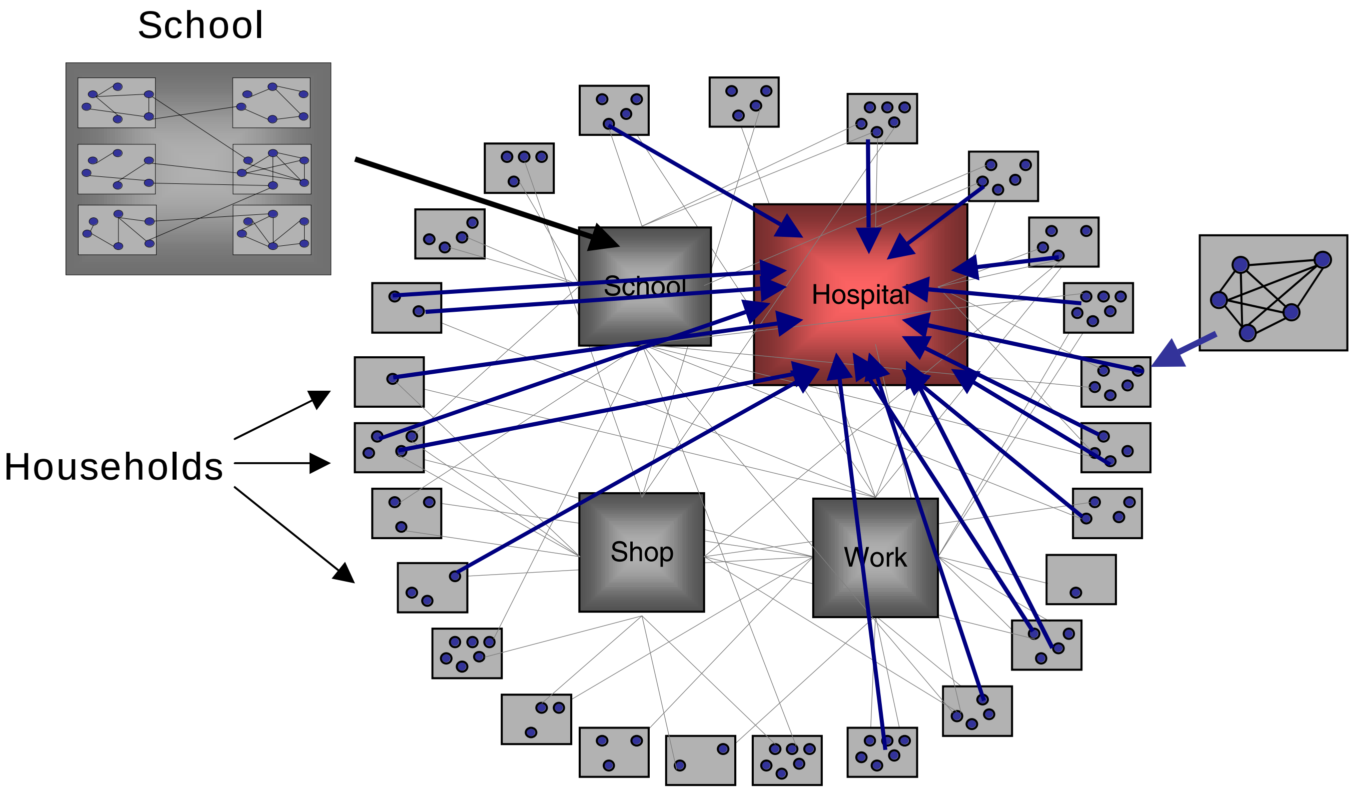
Activity:

Each student will be creating his or her own contact network. This activity will begin with one individual student and end with the entire class connecting their networks together at nodes. A n**ode** is a network junction or connection point.

1. Each student will have many shapes representing their own network. Assign one polygon to each of the following: circle = you; square = home; rectangle = mall or shops; oval = grocery store; line (a piece of string) = links (also known as edges) that connect nodes.
2. After each student constructs their own small contact network, have them join other students at the central school (shaped as a large triangle in the center of the room, constructed by the teacher). The school can be large enough to contain divisions of classrooms and where each student may go throughout the day.
3. The teacher will then place a red cutout dot on one student's network at random. Let this represent a contagious contact disease like chickenpox or the fictional 'cootie-itis." See how many students are affected immediately through a connecting node (this will depend on who they connected next to when everyone joined at the school triangle). Let one link between two nodes = one day until the disease appears. Ask the students to count how many days it will reach their home, grocery store, shops, etc., and estimate how many people they may infect in 7 days.
4. Let the students use mathematics to apply ratios or percents of students infected with the disease, and how many people were infected in the hypothetical seven day period (they will be counting family members, family members' contacts, people in the community they are in contact with in a seven day period, etc).
5. At the end, see if they can determine how many total people in the classroom contact network were infected with the hypothetical disease by the end of 1 week (7 days). You can use percents and ratios to incorporate mathematics into the data.

[1] Dr. Lauren A. Meyers, presentation of the University of Texas Environmental Science Institute's *Hot Science – Cool Talks* Outreach Lecture Series (Vol. 42), April 2006

For an example, see picture below. This represents a contact network designed by Dr. Lauren A. Meyers:



Part II: Continued for advanced grades or classrooms

For Further Discussion: Now that your classroom has completed a large sized contact network, you can add a level of discussion of theoretical models to predict epidemics. One question you can answer mathematically is whether an outbreak of one or a few cases will lead to a large epidemic. This is going to depend on the rate at which individuals are becoming infected compared to the rate at which they are leaving the infected group either by recovering or dying. We can calculate the ratio of those two rates using this formula[1]:

$$\frac{\text{Infection rate}}{\text{Mortality + Recovery rate}}$$

That ratio is called the reproductive ratio of the disease. It tells epidemiologists how quickly the disease is reproducing itself in the population. If the ratio is greater than one, that means that individuals are becoming infected faster than they are recovering or dying, thus the infected group will continue to grow in size leading to an epidemic. The higher the reproductive ratio, the harder it is to control the disease.[1]

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[1] Dr. Lauren A. Meyers, presentation of the University of Texas Environmental Science Institute's *Hot Science – Cool Talks* Outreach Lecture Series (Vol. 42), April 2006.