Building a Better Investigation:

Considerations for Planning Student Inquiry Projects

MSTA 2009 Annual Conference

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More information at:
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BUILDING A BETTER INVESTIGATION: CONSIDERATIONS FOR PLANNING STUDENT INQUIRY PROJECTS

Overview of this Session:

This session is intended to address the notion of inquiry, and in particular, one component of inquiry that is often most challenging for teachers to address: student designed investigations.

In this session, we are going to work through two different activities that could lead to student designed investigations. One of these essentially brings in the entire classroom as a group to design an investigation, which can provide some insight in how to use student questioning to generate a large scale investigation with all students in your class. The second is more typical, a situation where students see a particular challenge laid out for them, and they need to decide what particular approach or variables to work with.

Along with all of this come a variety of issues and concerns that teachers may need to consider. We'll show you how you can review these questions on your own in planning or with students to ensure the best possible outcomes for student designed investigations.

About the Presenters and Resources:

These resources are generated from the Michigan Mathematics and Science Teacher Leadership Collaborative (MMSTLC), a statewide effort to support instructional leadership at many levels in local schools, regional support agencies, and higher education. These resources are a part of the broader set of resources being provided to project participants to help them support other teachers in their schools and region.

For more information about the project or any of these tools, visit the MMSTLC Web site: http://mmstlc.net

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Nancy Williams is a science outreach consultant with the University of Michigan School of Education working specifically with the MMSTLC program. Prior to this role, she spent over a decade teaching at the Mecosta-Osceola Mathematics and Science Center, and has been involved in science education efforts at Ferris State University.

What does inquiry look like in the classroom?

Use this space to jot down an answer during the workshop.

So, what do you think about this question? What would you describe as "inquiry-learning"? We want to address this first, so that we can see how this plays into the student-designed investigations that will follow. The reason for such investigations is specifically to engage students in authentic inquiry about a topic or question that they have - not just to have them do an experiment that someone else designed.

The problem is, inquiry means different things to different people. It is a term that has been used SO OFTEN in the education community with different descriptions attributed to it that it no longer makes sense to define. Sure, you can define it on your own or with a small group, but when you try applying it to others, even if you tell them your definition, they are going to use what they think of for this term from their own experience. So, as the authors of Ready, Set, Science! (an excellent book about science education that we would recommend every science teacher read!) said, let's drop the term, and just describe the work of "doing science", and a range of learning opportunities and instruction that support the learning of science.

However, with that said, the National Science Education Standards identified five essential elements of inquiry teaching and learning that apply here. They are:

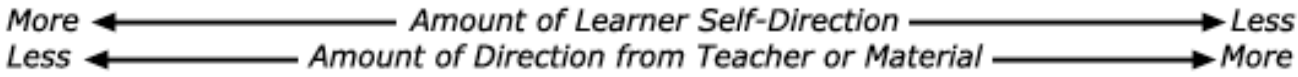
- Learners are engaged by scientifically oriented questions
- Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
- Learners formulate explanations from evidence to address scientifically oriented questions.
- Learners evaluate their explanations in the light of alternative explanations, particularly those reflecting scientific understanding.
- Learners communicate and justify their proposed explanations.

More detail on these can be found here:

http://science-education.nih.gov/supplements/nih6/inquiry/guide/info_process-b.htm

Essential Features of Classroom Inquiry and Their Variations

Essential Feature	Variations			
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies a question provided by the teacher, materials, or other source	Learner engages in a question provided by the teacher, materials, or other source
Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner is directed to collect certain data	Learner is given data and asked to analyze	Learner is given data and told how to analyze
Learner formulates explanations from evidence	Learner formulates explanations after summarizing evidence	Learner is guided in process of formulating explanations from evidence	Learner is given possible ways to use evidence to formulate explanation	Learner is provided with evidence
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner is directed toward areas and sources of scientific knowledge	Learner is given possible connections	
Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanation	Learner is coached in development of communication	Learner is provided broad guidelines to use to sharpen communication	Learner is given steps and procedures for communication



Source: National Research Council. 2002. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, D.C.: National Academy Press.

The table above is from the National Science Education Standards, and can help us define what we are looking for in an inquiry learning classroom. This is often useful to provide teachers a sense of what the instruction looks like.

There are other variations that we can use to explore these concepts, though the notion of a continuum is probably most appropriate to better understand our own practice and where we might want to be.

We can look at this continuum for a number of different considerations, including those below:

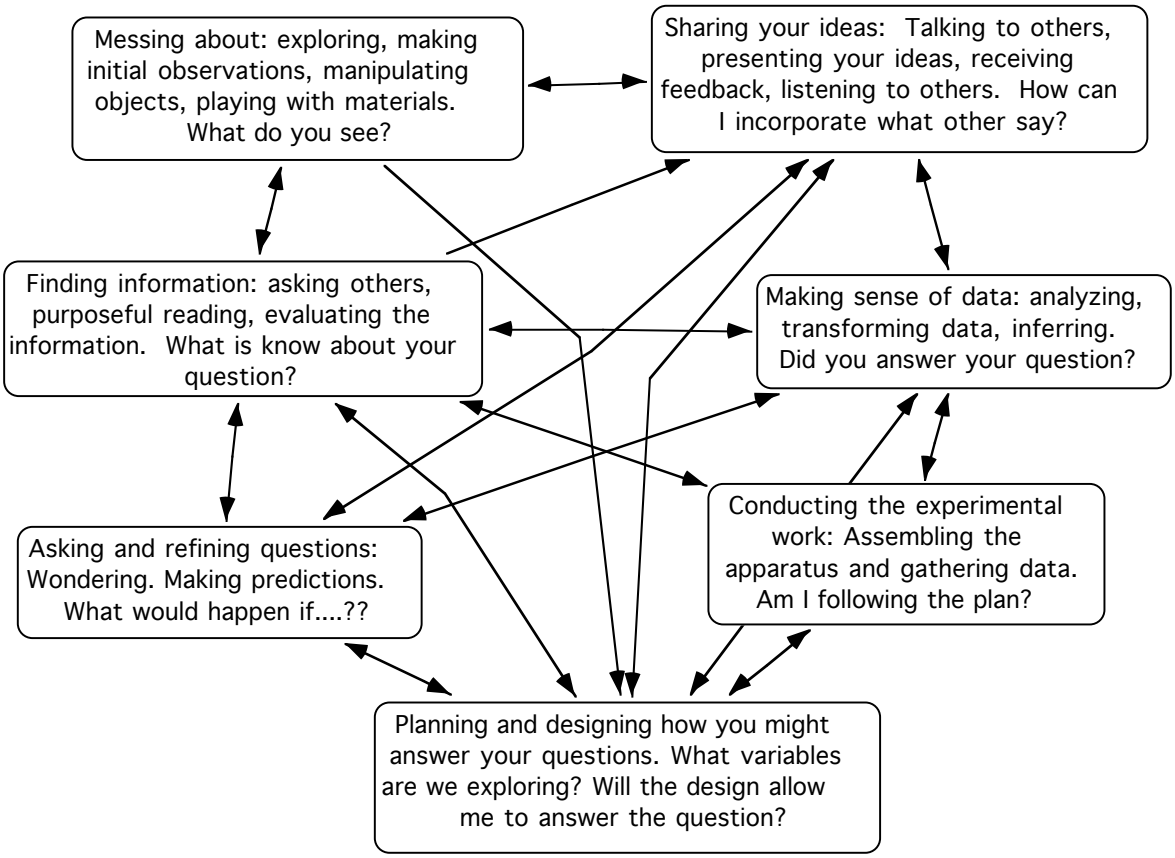
Hands on: Do students have more time working with the things they are observing or investigating, or is this done more through demonstration?

Questioning: Are the investigations based on teacher questions, student questions, or some mix?

Experimenting: Do students have more control over what happens in an experiment, or are experiments more controlled in terms of materials, variables explored, and procedures?

Collaborative: Do investigations in the classroom rely on groups of students taking different roles? Do students have an opportunity to discuss the design or results of an investigation with each other to determine conclusions?

The concept map below also helps describe the processes involved. While we won't explore it so much here, it can be useful for some to think through their investigations.



Inquiry Skills

Before we get into the activities, there is one more consideration and tool that might be valuable in considering the elements that students would want to incorporate in an investigation. While the Michigan Curriculum Framework and Grade Level/High School Content Expectations don't specifically address the types of investigations that all students should do, they do address the inquiry skills that all students should develop. The table below and on the following pages lists all of the inquiry skills on a grade-by-grade level that should be mastered by students. These standards and expectations should be inherent in all investigations that students do in their science work in school. Many of them, as you can imply from the items in the table, cannot be developed if students are not directly involved in the design of investigations that they conduct.

Thanks to Amy Oliver at the Allegan County Mathematics and Science Center for compiling this table.

A Look at the Science Processes Across the Grades (K-7)
(Inquiry Process, Inquiry Analysis and Communication, Reflection, and Social Implications

Grade	Content Expectations
Kindergarten	• Make purposeful observation of the natural world using the appropriate senses. • Generate questions based on observations. • Plan and conduct simple investigations. • Manipulate simple tools (ie. Hand lens, pencils, balances, non-standard objects for measurement) that aid observation and data collection. • Make accurate measurements with appropriate (non-standard) units for the measurement tool. • Construct simple charts from data and observations. • Share ideas about science through purposeful conversation. • Communicate and present findings of observations. • Develop strategies for information gathering (ask an expert, use a book, make observations, conduct simple investigations, and watch a video). • Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.
1st	• Manipulate simple tools (ie rulers, thermometers, rain gauges) that aid observation and data collection. • Recognize that science investigations are done more than one time.
2nd	• Manipulate simple tools (ie meter stick, measuring cups) that aid observation and data collection. • Make accurate measurements with appropriate units (meter, centimeter) for the measurement tool. • Construct simple charts and graphs from data and observations. • Develop strategies and skills for information gathering and problem solving (Internet, technology tools). • Recognize that when a science investigation is done the way it was done before, similar results are expected. • Use evidence when communicating scientific ideas. • Identify technology used in everyday life.

3rd	• Plan and conduct simple and fair investigations. • Manipulate simple tools (ie spring scale, stop watch/timer) that aid in observation and data collection. • Make accurate measurements with appropriate units (Celsius, grams, seconds, minutes) for the measurement tool. • Summarize information from charts and graphs to answer scientific questions. • Share ideas about science through purposeful conversation in collaborative groups. • Communicate and present findings of observations and investigations. • Develop research strategies and skills for information gathering and problem solving. • Compare and contrast sets of data from multiple trials of a science investigation to explain reasons for differences. • Use data/samples as evidence to separate fact from opinion. • Identify current problems that may be solved through the use of technology. • Describe the effect humans and other organisms have on the balance of the natural world. • Describe how people have contributed to science throughout history and across cultures.
4th	• Manipulate simple tools that aid observation and data collection (ie. Graduated cylinder/ beaker). • Make accurate measurements with appropriate units (ie. Millimeters, milliliters, liters) for the measurement tool.
5th	• Generate scientific questions based on observations, investigations and research. • Design and conduct scientific investigations. • Use tools and equipment (ie meter tapes) appropriate to scientific investigations. • Use metric measurement devices in an investigation. • Identify patterns in data. • Analyze information from data tables and graphs to answer scientific questions. • Evaluate data, claims, and personal knowledge through collaborative science discourse. • Communicate and defend findings of observations and investigations using evidence. • Draw conclusions from sets of data from multiple trials of a scientific investigation. • Use multiple sources of information to evaluate strengths and weaknesses of claims, arguments or data. • Evaluate the strengths and weaknesses of claims, arguments and data. • Describe limitations in personal and scientific knowledge. • Design solutions to problems using technology. • Describe how science and technology have advanced because of the contributions of many people throughout history and across cultures.
6th	• Use tools and equipment (ie. Sieves, microscopes) appropriate to scientific investigations. • Evaluate scientific explanations based on current evidence and scientific principles. • Describe what science and technology can and cannot reasonably contribute to society.
7th	• Use tools and equipment (ie. Hot plates, pH meters) appropriate to scientific investigations.

Note: This table lists all of the Science Processes GLCEs for Kindergarten and then only the additional GLCEs for each grade (1st-7th) beyond the Kindergarten GLCEs. It also lists repeat GLCEs from Kindergarten but shows how they are expanded with red lettering.

Created by Amy Oliver, Allegan County Math & Science Center, Allegan AESA, January 9, 2008.

Sample Investigations

The following investigations are from lessons used in the curriculum materials from the Learning Technologies in Urban Schools project (LeTUS), funded by the National Science Foundation and used and tested in classrooms in Detroit and Chicago.

The first of these uses "Cooties", a program designed for handheld computers. While we will use these during the activity, a separate activity is included in the lesson at the end of this handout from those curriculum materials.

This activity is useful for initiating conversation among students about the possible variables in an investigation, and how you could isolate these variables.

The second activity is a variation of an activity from the unit, "Why Do I Need to Wear a Bike Helmet?", which investigates force, motion, and Newton's Laws of Motion. The variation is useful in getting students to think through the possible variables that would make the cart travel faster or slower down the ramp, or alternately, would give more or less force to the cart for an impact with an object at the bottom of the ramp. It is a precursor to using the ramps and carts to explore concepts of velocity, impact, and momentum, among other things. It also is a precursor to a final design, where students would try to create a helmet (or alternately, restraint) to keep an egg from cracking on a collision at the bottom of the ramp.

What Can Students Investigate?

The content of a student designed investigation can vary considerably. However, if you are moving from a traditional experiment or demonstration to having students begin to design and investigate topics of their own, you may want to consider the following options:

- Have students investigate different questions on the same topic. For instance, if studying simple machines, some students could investigate the effect on distance and effort for a lever, others for a pulley, and others for a ramp.
- Have students investigate different variables that can affect an outcome. The ramp and cart example is great for this - some students think the mass will affect the speed, others the height or slope of the ramp, and a variety of other variables.
- Have students create different designs or solutions to a problem. In some cases, the problem might be the same for everyone (i.e. how do bridges work to carry a large load?), but they might be able to create their own unique solutions to be tested.
- Have students use different approaches to investigate the same phenomena or variable. For instance, in the cart/ramp example we used, some students might try to test the impact of the slope on speed by using a smaller ramp, others a larger ramp, but with the same slope.
- Have students attempt to replicate the results of a previous investigation. This aspect of science is very critical, yet rarely stressed in classrooms. Have students take some other investigation that another group of students did and see if they can get the same or similar results to test the validity of the first experiment.

Considerations for Investigations

The following are all different types of investigations or aspects of an investigation that one might consider in working with students to design and implement their own investigation.

Investigations that use models

This is an important topic in that students can often struggle with how a model can represent particular concepts or phenomena that are observed in the real world, but cannot be tested themselves. Rather than ignore using models altogether, teachers should consider the following in how they are used in a student investigation:

- How do you know if a model should be used?
- How do you create the model?
- What aspects of the real object or phenomenon need to be included in the model, and what ones are less important?
- How can the wrong model affect a student's investigation?
- How can students transfer their investigation of the model to the real world?
- How is using a model in an investigation different from using one in a teacher-led demonstration or controlled experiment?

Strategies for data collection and presentation

We often rely on some basic tools to get students to collect or present data, and when we do so, we usually tell them what to do (or provide it in a handout). And, even then, we know some students struggle with this. Even more challenging... if we really want students to design and conduct their own investigations, they need to know what data they will collect, how to collect it and report it, what format or tools might be most appropriate to help analyze it, and how best to present it for their own analysis or for the communication of their investigation to others. Considerations include:

- How do you get students to understand the different types or qualities of data they might collect?
- How many (and which ones) different representations of data do you present to students?
- What representation (tables, graphs, charts, maps, etc.) are best for the different kinds of analysis we do in science?
- How can we best support students in understanding how to "read" different types of data to analyze it effectively?
- How do we get different groups of students who are investigating different aspects of some scientific phenomenon to represent their data in ways that can be shared?
- How can we get students to recognize and understand the units and labels we use in presenting data?

Working with variables in investigations

One of the biggest challenges for students in designing and conducting investigations is that they often struggle with the selection and control of variables in an experiment. Research suggests one of the more difficult concepts for students to understand is how to isolate and manipulate variables. Yet, this is one of the more critical concepts in designing and conducting investigations. Before facilitating the student designed investigations, teachers should consider the following:

- How do you get students to understand what variables are, and which variables can be identified for any given phenomenon?
- How do you introduce variables to students so that they understand and don't develop misconceptions?
- Which variables can be controlled in an experiment, and how do you do this?
- How do you have different groups of students investigate different variables and compare results?
- How do students know which variables are independent and which are dependent?
- How do you work with experiments with more than 2 variables?

Problem-based learning investigations

One of the approaches that we often try to use in engaging students in science is the idea of addressing a problem. For example, many teachers, when addressing concepts of force and motion, prefer to do so by presenting students with a problem to address, such as the need for a way to make car travel safe. This problem then drives the unit and any investigations that students may conduct within the unit. Problem-based learning is the way that most medical doctors in this country are now trained; by using problem situations as a way to learn about anatomy, physiology, and the natural problem solving role that doctors engage in. Considerations for using problems to drive an investigation include:

- How do you find or create good problems to address specific content understandings and expectations?
- How do you build problem solving skills and introduce problem solving strategies?
- What details of a problem do you want to address and what ones do you skip?
- How might you have students create investigations to address the problem?
- How do you manage having different groups of students address different aspects of the problem?
- How do you identify experts who can help your students address the problem?
- How do you resolve and assess a problem-based investigation?

Design based investigations

Recent changes in science education, including the new standards and grade level expectations here in Michigan, often exclude practices and concepts used by a particular group of scientists: engineers. Yet, students are often most engaged in learning when focused on creating something to address a particular task. Design-based learning is a specific version of problem-based learning (and ideally, involves inquiry on some level) that gets students to create designs that address a particular problem. Considerations include:

- How do you identify or create interesting projects to have students address through design?
- Is there a specific process to design-based learning that is different than the scientific process?
- What aspects of the design process are critical to helping student understand the underlying science?
- How do you assess a design?
- How do you know the design is authentic?
- How do you differentiate the design from the underlying science concepts in your lessons, investigation, and assessment?
- How do you find people who can support you and your students in understanding the process and creating an authentic experience?

Station or activity based investigations

Many teachers are familiar with the use of stations as a way to organize and facilitate the learning when there are multiple skills or concepts to address, or when facilities or equipment limit the ability of students to all work on a similar investigation at one time. Yet, these often can lead to directed instruction or planned investigations where the student has little input, and where there is little depth to the learning. Teachers should consider and reflect upon the following before using such an approach with investigations:

- How do you identify activities or topics for individual stations?
- How do you set up the stations to allow for students to design their own investigations?
- How do you prepare for the use of stations to investigate a particular concept?
- How do you assess student work and understanding with this approach?
- How can students share their results and work to build understanding among the whole class?
- How do you effectively monitor and facilitate instruction during the use of stations?

Collaboration strategies for investigations

Teachers are often frustrated or challenged by getting all students in a group to work together to conduct, analyze, and present their investigations. Even if teachers are comfortable with having students work together on an experiment, they are generally challenged in using the experience to build understanding among students, and in assessing individual learning and effort. Teachers need strategies to get them to use collaboration as a learning strategy in general in their classrooms, and, in particular, to further the learning and efforts of student-designed investigations. Before engaging in collaborative student investigation, teachers should consider:

- How can you organize the classroom to support collaboration?
- What is the function of collaboration with respect to scientific investigations in the classroom?
- What aspects of collaboration can happen naturally, and what needs support and structure (and incentive?) from the teacher?
- What are appropriate numbers and roles for different types of activities?
- How do you vary the roles to ensure that all students develop a full range of skills and knowledge during investigations (and you don't end up with that one student as record-keeper or other lower-functioning role all the time)?
- How is collaboration different from "cooperative learning" and how does this play out in terms of science investigations?
- How do you assess collaboration and individual effort and understanding (or do you need to)?

Assessing individual and group work

One of the most critical issues for teachers to address in using an inquiry approach, and specifically, in doing student designed investigations, is the assessment of individual and group work. Considerations include:

- How do you organize groups to make sure that you know what students are doing and what is expected of each?
- How do you assess individual work within a group task?
- What aspects of the investigation do you assess?
- How can you identify learning concerns for individual students when assessing a group activity?
- How do you respond to an individual's learning needs when working with a group task or investigation?
- How do you ensure that all students in the group have the appropriate skills and understanding from a group task?
- How much can you expect students who didn't investigate a particular concept to learn from what other students (who did investigate that concent) present, and what gaps should you fill in?
- How do you grade individual and group work for an investigation (as opposed to assessment, which is different!)?

Strategies for sharing data within and among classes

One of the critical elements of the scientific process is the presentation of one's work to peers for review and collaboration to help understand the phenomena being studied. Following this logic, as well as the idea that students learn from their peers, students need to have an opportunity to collaborate with each other to investigate particular concepts in different ways and share the results of their studies. It may be that they simply share results with each other in class, or that they share data and observations with students from other classes, either in their school, region, or across the world. Such efforts are often needed to help students verify their results, and understand the differences or similarities in process and results that others might find. Some possible considerations for teachers include:

- What kinds of investigations are appropriate for such data sharing and collaboration (and what common qualities do they have)?
- How do get students to communicate their data with each other?
- What strategies can teachers use to get students to review and evaluate each others' data and results?
- How can you find other groups of teachers or students to collaborate with on different investigations?
- How should such data sharing be built into the planning and implementation of the investigations?
- How can you get students to communicate and collaborate other than through having the teacher communicate findings? What is most effective for the context?

Presentation of investigations

There are several aspects and approaches to presenting the results of an investigation, and we often choose one format, which rarely turns out well (presenting in front of the class in an oral presentation with visuals of some sort). Some considerations include:

- What aspects of an investigation are critical to present, and does this vary based on the stage of the investigation?
- What are some different presentation approaches that can be used?
- How do you prepare students for presentations?
- How do you get students who are listening to the presentations to become active listeners (or be responsible for knowing about what is presented)?
- How do you assess presentations?
- How do you follow up and debrief presentations to provide useful feedback on both content and presentation skills?
- How do you effectively bring all of the information from different presentations together to better understand all of the content issues

Lesson 2
Spread of Disease Activity

OVERVIEW AND OBJECTIVES
Learning Objective
Using ideas generated from observations and discussions of the anchoring event, the spread of disease activity, students will identify the rapid rate of transmission and the danger of the lack of outward symptoms.

Assessment Criteria
Student discussion should include the rate of transmission and the lack of identifying symptoms until tested. Connections to real world scenarios should be made.

PREPARATION
Set-up
In this lesson you will need a basic solution and a pH indicator solution.

If using the baking soda solution, dissolve 30-40 teaspoons of baking soda in 2 quarts of distilled water. Care should be taken to get as much of the baking soda into solution as possible, this can be done by either stirring or shaking the solution. When using the solution, let the undissolved baking soda settle to the bottom before removing the top solution. This is done so that the "disease source" looks the same as the other cups of water. Students should not know that there are two solutions present.

Molecular weight of NaOH is 40 therefore, for a 1M solution you would put 40 grams into 1 L of water. So for a 0.1 M solution, you would put 4 grams into 1 L of water, but you don't need that much so you really would only do 2 grams into 500ml of water and share it with the other teachers in the building because you still have too much.

pH indicator solution: if using the red cabbage solution, either boil a cut up cabbage for 15 minutes and then collect the solution or blend the cabbage in a blender with distilled water

Science Understanding for Teachers

Please refer to the previous ***Science Understanding for Teachers*** for basic patterns of disease transmission.

Technology

Palm Pilot application: Cooties
Please refer to the hi-ce palm website: www.hice/palm and the Cooties application for additional information. A Cooties tutorial will be included in the curriculum when it becomes available.
Please refer to the hi-ce website for additional information on Model-it.

Cooties

These Cooties applications can be used for investigations looking at:

Who starts the spread of the disease?
How many people start with the disease?
The probability of infection per interaction.
The people (if any) who are immune.
The presence or absence of a testing station (importance of knowing your status).
The length (if any) of latency.
The variability of latency.
Lethality of the infection.

Model-It

The Model-It Activity is structured in four lessons. In the first lesson students are introduced to computer based modeling and connections between various models presented in the unit are discussed. Students develop driving questions that they are interested in answering by creating a cause and effect model using the computer modeling program Model-it. Following this introduction, students then participate in a teacher led construction of a simple model about the spread of disease in a community. Students can practice the modeling process during this demonstration of Model-it. The last lesson in this sequence is students constructing their own models that address a particular question that they are interested in answering. This question can be directly connected to the teacher question or to the disease that they are investigating. Students then present their models in the final learning set during their group presentations.

Lesson 1

Chaos Activity/Intro to Palms

OVERVIEW AND OBJECTIVES

Learning Objective

Using ideas generated through the initial spread of disease activity, students will participate in a spread of disease simulation and discussion using the Palm application, Cooties.

Assessment Criteria

Students' discussion about the interaction history and the spread of disease will be critiqued for reasons, logic and explanations. Explanations need to be connected to the data that students collected in the initial activity. Explanations can be written and turned in for assessment.

Purpose

Palm OS and Cooties are a new technology that allows models of how diseases can spread to be built.

Using them, students incorporate new material and concepts in an investigation about how a disease can spread. Students apply what was learned in the simulation investigations to humans.

They can be modified to incorporate variables covering bacterial and viral characteristics.

PREPARATIONS

Set-up

SEE TEACHER RESOURCES FOR "COOTIES QUICK START GUIDE"

Materials

- Classroom set of palms
- Elmo to project the palm
- TV
- ***Student Worksheets/Chaos Activity***
- ***Student Worksheets/Chaos homework***

Time

Two fifty-minute periods.

What are PalmOS devices?

Small hand held computers that can "talk" with each another through infrared sensing devices.

What is "Cooties"

A PalmOS application program that can be used to model the spread of disease. This application allows for variables to be manipulated and specific infectious disease concepts to be stressed. Cooties is:

- able to incorporate a wide range of variables,
- able to rerun a simulation in order to investigate how a disease spreads.

Make certain that all the palms are set to a new game and that the appropriate number of carriers have been set. For the Chaos activity, the initial carriers should be 1-2. For the Cootie Island activity, each of the islands should have one carrier. Take time to learn the Cooties application. Make certain that one or two palms have been set as initial carriers.

Refer to the Cooties application quick guide at the end of the session for a detail explanation for how to set the Cooties application so that different parameters of the disease are set appropriately.

This is an example of what a PalmOS device would look like after it has been turned on. The power button on this palm is the small button on the lower left hand side of the machine. Briefly explain to the students what the different buttons on the hand held computer can do. Students need to be instructed on how to handle the instruments and be reminded that they will break if handled improperly. If using the hand held computer over several days, a useful technique is assigning specific computers to specific students so that they are responsible for the care and safe keeping of the specific machine. Numbers can be affixed to the bottom of the computer. Students need to realize that the hand held computer will be taken away if it is not handled properly.

INSTRUCTIONAL SEQUENCE

INTRODUCING THE LESSON

Review the importance of models in scientific research. Strengths and weaknesses of models need to be addressed.

In using this simulation of disease models, connections need to be made to the initial spread of disease activity and questions need to be asked about what are the shortcomings and strength sof the two models.

Show the students what a PalmOS device looks like and what the different parts of the hand held computer are.

Explain how the hand held computers will be the computer technology that will be used with this investigation. A small handheld computer running "Cooties" is capable of interacting with other hand held computers and can pass information from one to another. This interaction is done through infrared ports. Students would have used infrared ports with TV/video remote controls.

The value of using simulations in student learning can be explored in student conversations.

CONDUCTING THE LESSON

Introduce the PalmOS device and Cooties

Pass out PalmOS to the students, placed upside down on their tables. Explain to the students the importance of leaving the batteries in and to tell you if they ever come out. Point out where the infrared port is at the top of the PalmOS. Students will be lining up these ports to interact. Have students turn over the PalmOS.

This initial Cooties investigation is about out how a disease can spread through a population. Students are introduced to the palms, to the cooties application and optionally to the picomap application.

Subsequent sessions will modify this investigation in order to incorporate additional scientific concepts.

Turn on the PalmOS by pressing the green button on the left side of the handheld computer. Have students explore the different buttons on the palm as a way to become familiar with the PalmOS. If possible use an Elmo (a small projector camera) to project the PalmOS on a projector so that students can see what the different buttons do as you take them through the different buttons and controls of the PalmOS.

Stress to the students that these are fragile computers and care needs to be taken in handling them.

Show students how to write using the keyboard in the note function of the PalmOS.

1. Have students enter the note area of the Palm by pressing the note function button.

2. Have students select new note.

3. Have students write their name in the Palm by touching the ABC in the left bottom of the writing area in the bottom part of the screen.

4. After students finish typing their name in, have students click done.

Allow students to ask any questions that they might have about the PalmOS.

If time permits, continue with the lesson. Hand out ***Student Worksheet/Chaos Activity.***

Explain to the students that they are now going to use the PalmOS handheld computers to do a spread of disease activity. Ask the students if they remember the spread of disease activity that they did at the start of the unit.

Ask students what it was, what did they learn and what had they learned since they did the initial activity about how diseases spread. Look for specific reference to the in-class activities, readings and content about specific diseases that they are investigating.

Chaos Cootie activity

1. Make certain the PalmsOS devices are programmed and ready to go. Only one or two palms per class should be set as the initial carrier and everyone should be set to zero percent immunity (one possible option is to set several palms to 100% immunity). Set incubation time for 1 minute, so students can interact with other several students.

2. Instruct the students to turn on the Palms.

3. Select the "Cooties" icon by clicking on the phage symbol with the stylus.

4. After selecting the "Cooties," the opening page of "Cooties" should appear.

Have the students put a name in the field that asks for a name as before, the name can be the same or different from the previous activity. Once the names have been entered, have the students press go and start interacting.

The name can be an assumed name or the name of a pet. Care needs to be taken so that students do not assign blame or point fingers as a result of being infected. If you believe your students can handle the social pressures inherent in the simulation, have them put their own names in the field. If you believe that students will finger point and blame the disease source, have students place assumed names in the field. This will make the game more complicated for the students to follow because they will still say the real name (the name that they know) and not the assumed name. Once the names have been entered, have the students press go.

Allow students to press go once they have identified and located the first person they want to interact with and then press the meet button when both palms are on a desk facing each other. Allow students to move about the room interacting with other students. An interaction can occur only after two students line the hand held computers up with the infrared ports facing each other and one student presses the meet button.

If the hand held computers return an error message or freeze, they can be unfrozen by resetting them using the reset button on the back of the computer. This button can be depressed by using the point hidden under the tip of the stylus. The cap of the stylus will unscrew revealing a point that will fit into the reset hole/button.

Sidebar
Once a palm has been infected the face on the coodle will goes sad.

Have students fill in the ***Student Worksheet/Chaos Activity***.

When students are done interacting, have them return to their seats. Students can interact with as many or as few students as they would like. This can be an interesting point of discussion—how many coodles did your coodle interact with, did your coodle interact with any sick coodles, if so why? Could you tell if all the coodles were sick or healthy? What indicated if your coodle was sick or not?

Ask students what happened.
- Can students identify who was the source of the disease? Why or why not?
- What might be one way that they could design an investigation that would allow them to identify the disease source?

Ask the students why some students didn't get sick?
- Issue of immunity or of whom they interacted with might be raised.

How could they identify what might be the case?

How was this activity similar or different from the initial spread of disease that they did at the start of the unit?

CONCLUDING THE LESSON

Why use "Cooties"?

Have students brainstorm why the "Cooties" application might be useful for a unit on communicable diseases.

Potential ideas that students might generate include:
- Disease is spread through interaction, with the handheld computer and the program; we can interact without getting sick ourselves.
- We can repeat the activity over and over again.
- We can add different diseases to the computer.

Have the students describe in their own words what "Cooties" allows them to do.

Students should describe that Cooties allows them to model how a disease can be spread through a population.

Have a discussion about what a model is and why is such a model important.

- A model is a representation of a real world situation that can be manipulated in ways that would not be possible for the real world.
- Different parts of the model can be tested to see what happens when variables are changed and if these variables behave as predictions have them acting.
- The strengths and weaknesses of models should be explored with the students.

Ask the students if they have modeled how a disease can spread through a population before?

- Students should refer back to the initial spread of disease activity that they did at the start of the curriculum.

Additional questions that can be asked include:

- Do they have any ideas about why one model might be better than the other?
- What might the new technology allow them to do that couldn't be done with the liquid spread of disease?

Have students finish the ***Student Worksheet/Chaos Activity.***

ASSESSMENT

Have students explain why they were or were not able to identify the initial carrier. How could they have done this activity so that they could have identified the carrier?

HOMEWORK

Student Worksheet/Chaos Homework

Name_____

Home Room _____

Date_____

CHAOS ACTIVITY

Using the Cooties application, participate in a spread of disease activity. After the activity, write down all the interactions that your Coodle had in the box that has your Coodle's name on the first line. After identifying all the coodles that your Coodle interacted with, find out the names of the coodles that that they interacted with. Fill in the chart.

Your Coodle_____

1. _____
2. _____
3. _____
4. _____
5. _____

First Interaction_____

1. _____
2. _____
3. _____
4. _____
5. _____

Second Interaction_____

1. _____
2. _____
3. _____
4. _____
5. _____

Third Interaction_____

1. _____
2. _____
3. _____
4. _____
5. _____

Fourth Interaction_____

1. _____
2. _____
3. _____
4. _____
5. _____

Fifth Interaction_____

1. _____
2. _____
3. _____
4. _____
5. _____

How many coodles did your Coodle interact with?

_____
_____
_____

Identify where on the list your Coodle's name is. Highlight all the names that are above your Coodle's name. Now how many coodles did you interact with?

_____
_____
_____

Can you identify the source of the disease? How?

_____
_____
_____
_____

Diagram out the chain of interactions that the coodles participated in.

Name_____

Home Room _____

Date_____

CHAOS HOMEWORK

Use the story below to help you answer the questions about the disease.
Joe had breakfast with Peter and Mike. Joe then went to class with Sally. Sally and Peter went to the movies. The next day, Joe, Sally and Peter were sick.

1. In the story described above, who was the initial carrier?

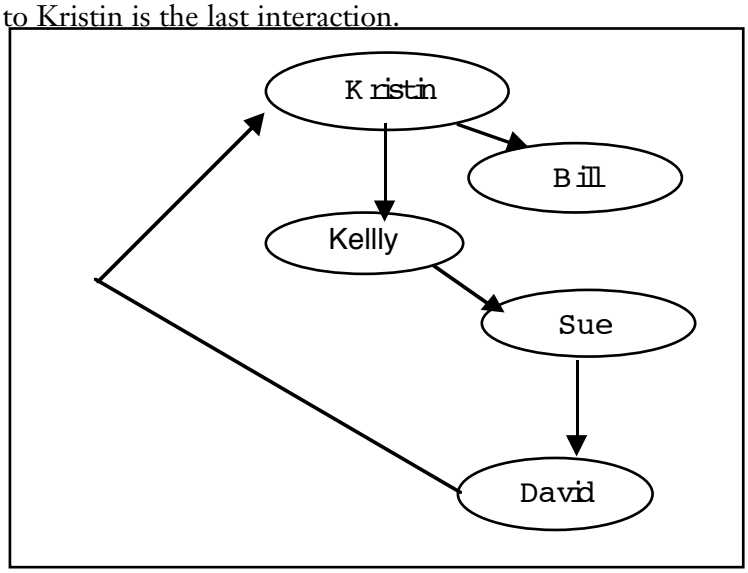
_____

_____

_____

2. Diagram out how the disease spread through the population.

3. Use the diagram of the different people's interactions to write a short description of the different interactions that the people had. Kristin starts the interactions. The arrow from David to Kristin is the last interaction.



_____
_____
_____
_____
_____
_____
_____
_____

4. Can you identify the initial carrier if Kristin, Sue and David got sick. Who was it? How do you know this?

_____
_____
_____
_____

5. Why didn't Kelly or Bill get sick?

_____
_____
_____
_____

Lesson 2

Cootie Island/Design and Investigation

OVERVIEW AND OBJECTIVES

Learning Objective

Students will design and carry out an investigation that identifies the initial carrier of the disease. From a set of observations and data, students will identify the initial carrier in their Cootie Island disease. Students will explain how they determined the carrier.

Assessment Criteria

Students' experimental procedure, data collection, data analysis and conclusions will be evaluated based on the criteria established during the bacteria investigation. Students will represent the spread of disease through the creation of a web illustrating the different interactions.

Purpose

The purpose of this investigation is to continue the spread of disease activity using a PalmOS application. The Cooties application will allow a range of variables to be varied and the spread of disease activity to be carried out multiple times. Students will apply skills that they learned in the bacteria investigation about creating good questions, data collection, and analysis and drawing conclusions. A similar format should be used so that students become more familiar with the different components of the investigation process.

PREPARATIONS

Set-up

For this activity, students need to work in small groups of 6-8 students, each with their own palm. Each group will need to have one palm that has been programmed as the initial carrier (See the quick guide in the teacher resources for additional information about how to program the application.). This palm should look the same as the other palms, it is important that students are not able to identify it. By labeling the classroom set of palms with numbers, you can easily keep track of the palms that have been programmed to be the infective palm.

Each group will work with individual palms that have been color coded to match an island color. These small groups will each make up an island. Therefore before class, it will be important to establish 4-5 areas in the room that will be an island. One possible way of identify these areas is by placing different pieces of colored paper on the desks or walls. These colors should then match the palm identifying color. Placing different color cards on different tables can identify the different island communities (multiple islands might be necessary due to the class size, groups should be in the range of 6-8 students).

Materials

- Classroom set of palms with the Cooties application set appropriately. Palms should be numbered and color-coded.
- ***Student Worksheet/Coodle Investigation***

Palm settings

Palm settings should be thought out previous to the start of the lesson. In pervious enactments of this lesson, an incubation period of 30-45 seconds was sufficient. You do not want to have the simulation set so that all the palms will get sick during the interaction. If all palms get sick, students will not be able to identify which palm was the initial carrier. Students will still be able to design investigations to identify the initial carrier.

Palms should be marked with different color markers that correspond to the colors of the different islands.

Time

One- two fifty-minute periods.

INSTRUCTIONAL SEQUENCE

INTRODUCING THE LESSON

Pass out marked Palms.

Review briefly with the students the proper way of handling the palms.

Explain to the students that care needs to be taken while handling computers.

Explain to the students that these palms have been programmed and contain a disease simulation program.

Go over the different parts of the hand held computers again.

CONDUCTING THE LESSON

Initial Cootie activity

Review with the students how to run the Cooties simulation.

The students will go through this activity twice. The first time is to help students become familiar with the program. The second time is to have students conduct an investigation of their own.

1. Instruct the students to turn on the Palms.

2. Select the "Cooties" icon by clicking on the phage symbol with the stylus.

3. After selecting the "Cooties," the opening page of "Cooties" should appear.

4. Allow students to move to the island location and tell them that they can only interact with people in their groups. They should press go once they have meet the first person they want to interact with and then press the meet button. An interaction can occur only after two students line the hand held computers up with the infrared ports facing each other and one student presses the meet button. As soon as one person in their group shows that they are infected, students should stop interacting.

5. Tell students to now press go and to begin interaction. Have students stop after the first Coodle gets sick.

Time will be variable for these different simulations.

One way to get students to stop interacting is to have set an audible signal that will signal the end of interactions. One such signal is to have a cassette player playing music that the owner of the first identified infected Coodle gets to turn off.

Making sense of data

Discuss with students the following questions, they will be trying to identify:

- who got me sick?
- who is the initial carrier?
- how can you identify what palm was the initial carrier?

Have students think back to the initial spread of disease activity and the homework assignment that was associated with this activity.

Mapping the data

Student now need to record the names of the Coodle that their Coodle interacted with on a sticky. Have students use one colored sticky to represent infected and another color sticky to represent uninfected.

Have students place the stickies on a large butcher paper or piece of white board.

Have the students connect the web in the order of interactions that they can identify. This is similar to the homework that students have done in previous Spread of Disease activities.

If possible, have students identify which of the Coodle started the disease

Identifying the initial carrier: Design, carry out, analyze and draw conclusions

In this next round, the students will design and carry out an investigation using Cooties.

If identification is not possible (and it probably won't be) have students create a hypothesis about which is the initial carrier.

The ***Student Worksheet/Cootie Investigation*** should be passed out for the students to complete.

Have students develop a procedure that will allow them to address their hypothesis.

Have students carry out their investigations.

Have students collect their data (the names of the coodles and the interaction path).

Have students analyze their data.

Have students draw their conclusions.

In creating these investigations, students should use the same guidelines that they used during the bacteria investigation. If students cannot identify the initial carrier from their investigation, have the students refine the investigation using the results of this second trial.

CONCLUDING THE LESSON

Have students come back to a whole class discussion and talk about the different investigations that they did.

Have students compare the different models of the spread of disease activities that they have done.

Tell the students that now they will be building models on the computer about the spread of disease and how disease can impact the whole system.

ASSESSMENT

Have students finish ***Student Worksheets/Coodle Investigation***.

Name_____

Home Room _____

Date_____

COODLE INVESTIGATION

What is the final question that you want to investigate?

_____

_____

_____

How could this question help you understand how good friends make you sick?

_____

_____

_____

What are the independent and dependent variables?

_____

_____

_____

How are the independent and dependent variables related?

_____

_____

_____

What is the hypothesis you want to test?

_____

_____

_____

Procedure

Write out your investigation. You might want to write this out in steps. Make certain you pay attention to your hypothesis and what you are using in your experiment as you create your procedure.

Prediction

Data collection

Use a table and/or drawing to organize your data. When you organize your data, you need to include data or information on the:

- Independent variable (that you change during the experiment).
- Dependent variable (variable that is measured).
- Different trials that you ran for your experiment.

Describe in words what you observed as you collected the data. Make certain to include that you will need to use in your analysis. Include any notes or description of your data that you think will be helpful later as you write your conclusions.

_____

_____

_____

_____

_____

Data analysis

What data will you use to answer your question? Why?

_____

_____

_____

Your data needs to be put in a diagram. This diagram should show the interactions that occurred and the sequence of the interactions.

Results

Explain what your diagram shows.

Conclusions

What have you learned? Does your data support your hypothesis?

You need to:

1) Make a claim that relates your results to your hypothesis. You need to relate your independent variable to the dependent variable.
2) Provide evidence to support your claim: use data you've interpreted in the experiment. Use your drawing/diagram.
3) Write your claim clearly: It needs to be a complete thought, and written in precise scientific language. Anyone who picks this up should be able to understand what you write.

Application to the Driving Question

How can your conclusions be connected to the driving question "How can good friends make you sick?"

and strain, collecting the liquid. Refrigerate both solutions until ready for use, if the solutions will not be used for several days, freeze until ready.

If using the phenolphthalein indicator, use only a drop per Dixie cup during the test phase. Care should be taken when using this solution, as it is a hazardous solution. Refer to the packaging of the solution for proper handing procedure.

Activity Set-up

Set up a classroom set of numbered containers, all filled half way with water except one which is filled with the basic solution (either the baking soda solution or the 0.1 M NaOH).

The container with baking soda or 0.1 M NaOH serves as the disease source. There should be no visible difference between the water and the basic solution. Fill only 1/3- 1/4 of the way to keep from spilling when mixing liquids. Cups should be handed out to students after the activity is introduced to them. Cups should not be reused from class to class or activity to activity as enough of the basic solution will remain and serve as a cross contaminant and cause confusion in the activity.

Carry out the spread of disease activity so that you are familiar with how the activity should go. You can set up a classroom set of cups and mix the liquid in the cups much like the students would- pour all of one cup into another cup and then pour half of the liquid back into the original cup. The two cups should end up with a similar amount of liquid as they had at the start of the exchange.

Cautions

Use caution if using the phenolphthalein powder, if possible have the students place the cups containing the solutions in a safe area that they can see the solutions but not spill the solution after adding the pH indicator. Phenolphthalein at high concentrations can cause birth defects and comes with a caution for use. Refer to the packing materials for more information.

If using the NaOH solution and the phenolphthalein indicator, instruct the students not to drink the solutions as they are harmful and to immediately wash with soap and water if any solution is spilled on their hands or clothing. Students should use eye goggles if using the NaOH solution or phenothphthalein.

Materials

- Classroom set of containers: plastic Dixie cups work well, number them with a marker if you want students to use the ***Student Worksheet/Keeping Track of the Spread of Disease***
- ***Student Reader/Spread of Disease Activity***
- Distilled water
- A dilute basic solution: A dilute solution of sodium hydroxide (0.1M NaOH) or a solution of baking soda in bottled water (30-40 teaspoons of baking soda in 2 quarts of water)
- pH indicator: Phenolphthalein pH indicator (can be found at www.carolina.com- buy the powdered) or water from a blended red cabbage can be used.

Time

One fifty-minute period.

INSTRUCTIONAL SEQUENCE

INTRODUCING THE LESSON

Review questions from last night's reading. Questions that you might use include:

- What was the reading about?
- What did they think about Nkosi, HIV/AIDS, the reading? (any of these questions can be used to start a discussion about the reading and the questions that they had to answer)
- Did it make you think of any questions that you wanted to answer?
- How did you think that Nkosi had gotten sick? Was he going to get anyone else sick?

HIV/AIDS is just one disease that can be spread. Have the students think about the last time they got sick.

Questions that might be used to get the students thinking about when they were sick could include:

- Did they have the flu this year? Have they been sick this year?
- Did they know who got them sick? Why or why not?
- Do they know how they got sick?
- Who can get sick?

Tell the class that they are going to do a short activity about how diseases spread. This activity will illustrate what they read about and how disease can spread through a community.

After the activity, they will discuss more about the spread of disease and what disease is, so they should keep these ideas in mind while doing the activity.

CONDUCTING THE LESSON

Spreading the disease

Hand out a container to each student; caution the students not to spill the solution. If it does spill, have the students wash immediately with soap and water. Each container should be filled no more than 1/3 full.

Have the students carefully share liquids with one another. Mixing should be done with pairs of students.

Have student A pour his or her solution into student B's container and then have student B pour back into Student A's container half of the liquid. This will result in a mixing of the two solutions

Have the students ask each other questions before or while they are sharing. This will serve to slow the students down and to allow them to interact as they might in a real world situation. In addition, answers can often serve as examples of how a disease can spread.

- Possible question to ask:
  - What is your favorite after school activity?
  - What did you think about the reading last night?

Questions that are used need to be connected to the spread of disease and referenced later in the discussion. This particular question can illustrate that students enjoy being together and so often put themselves in situations that can allow diseases to spread.

Remind students that mixing solutions is their choice; they can interact with as many or as few students as they want.

After sharing and mixing solutions with different students, have the students return to their seats. Students should do this for at least 15 minutes, you can stop and have a discussion and repeat if you'd like.

Teaching strategies
If using the baking soda and cabbage juice solutions, the color change will not be as dynamic and shocking for the students, but differences will be detectable.

Testing the solutions

At this point, tell them that a contaminant or disease had been identified in the population that they represented. This contaminant might be found in some of the containers and through their mixing activities it might have spread through the population.

Tell the students that a test exists to see if they have been infected. This test will show a color change with the addition of a second indicator solution if the contaminant is present.

Now add the pH indicator (red cabbage juice or phenolphthalein) to the mixed solutions. If using the red cabbage juice, an uninfected individual's solution will turn purple/red, (the color of dilute cabbage juice) and an infected individual solution will turn green or greenish blue. A range of green color might be seen, indicating how diluted the infecting agent became in the activity.

If using phenolphthalein, an infected solution will turn red-pink and an uninfected individual will stay clear. Use a dropper so that only a small amount of indicator is used.

ESTABLISHING LINKS TO THE DRIVING QUESTION

Have the students discuss what they did and what they learned. How has the activity added to what they know about the spread of disease?

- Questions that might be raised include:
  - What needs to happen in order for you to get sick?
  - How might we tell who is the original carrier?
  - Who might have started the disease?
    Do you know for certain? Why or why not?
  - Is it possible to track who started the disease?
  - How might they have modified the activity to do this, what would they have needed to do?

Continue the activity by having students write down who they shared fluids with and in the order that they shared. If you want you can have students use the ***Student Worksheet: Keeping Track of the Spread of Disease.***

Ask students if they remember whom they interacted with and in what order. If they do remember the source of the disease can be traced, but only if the students remember correctly. The results for such investigations are only as good as human memory and this is exactly how real epidemics are traced.

- Doing the activity this way is important because it shows how real epidemics can be traced. If students want to do the activity again but keep track of the students that they interacted with, let them do so. Can students now identify who started the disease?

After the activity, allow students to comment on what they did and what their feelings were about the activity. Encourage students to address each other when they share their ideas.

Make connections with the reading and the questions that were asked of the students in the spread of disease activity.

CONCLUDING THE LESSON

Have the students conduct a thought exercise of mapping out a pathway of transmission as a way to see if students understand how a disease can spread. By making a map of personal interactions and the knowledge of which individuals are sick, students should be able to (with practice) identify the initial carrier of the disease.

Students' initial destinations will likely not be very scientific at this time. Their description will probably also be very sketchy and terms may be used incorrectly. By having the students write this initial description of their experience with disease in their journals, they will have this to return to as they develop a more scientific understanding of disease.

Students should start to understand that a disease can spread through a community quickly and that it does not take many interactions.

Using the project notebooks, have the students write their initial understanding about how diseases can be spread through a community in their notebooks.

Have them respond to the driving question: "How can Good Friends make You Sick?" in connection to the activity that they just completed.

Their reflections should include reference to their activity and what happened in it as well as their personal feelings about the activity. They should include ideas such as:

- A disease can spread through a community quickly, it doesn't take that many interactions, and initially can be hard to track down where the disease started.
- It can also be hard to trace the spread of disease.

If they did the activity without writing down the names of the people they interacted with it also illustrates that people don't really remember who they interacted with and in what order.

ASSESSMENT

This discussion can be done in either small group settings or in a larger class discussion. If done initially in small groups, have the small groups join the larger class discussion and share what was talked about.

Using the discussion as well as the written responses, students' understanding of the activity can be assessed. This is an important activity for students to understand, as they will return to it again and again during the unit. Students should begin to develop an understanding of how a disease can spread and what it would take to track a disease.

Meaning is crucial for students. Through thinking and talking about what has happened students will begin to understand and retain the material being taught.

HOMEWORK

Have the students read the second section in the Student Reader (Lesson 2: Spread of disease activity).

Name_____

Home Room _____

Date_____

KEEPING TRACK OF THE SPREAD OF DISEASE

You probably realized in the spread of disease activity you just did, that it is difficult to remember with whom you interacted. Using the table, try and recreate what you did during the spread of disease activity. Use only your memory.

Interaction	***Cup number***	***Time of interaction***	***Is the solution positive for the contaminant?***

1. Can you identify where the disease started? How? If not, why not?

_____

_____

_____

2. Which cup can you rule out as being the initial carrier? Why?

_____

_____

_____

Now you and your classmates are going to do the spread of disease activity again but this time you will use the table to record your data as you do the activity. In addition, you will only interact with as many people as your teacher tells you that you are allowed.

Interaction	***Cup number***	***Time of interaction***	***Is the solution positive for the contaminant?***
1			
2			
3			
4			
5			

3. Using this method of keeping track of the interactions, can you identify where the disease started? Please explain your answer.

_____

_____

_____

_____

_____

_____

4. Which cup can you rule out as being the initial carrier? Why?

_____

_____

_____

_____

_____

_____

5. You can begin to eliminate cups and start narrowing down the carrier by looking at which cup is uninfected. What can you say about these cups? How can you eliminate others?

_____

_____

_____

_____

_____

_____

6. How would you explain the spread of disease?

_____

_____

_____

_____

_____

_____

7. What does the spread of disease activity tell you?

_____

_____

_____

_____

_____

_____

Name_____

Home Room _____

Date_____

SPREAD OF DISEASE

How can you and your friends get sick? How can you prevent yourself from getting sick?

First, we need to ask "how does a disease spread?". In class you did a "spread of disease" activity that showed how a disease could spread through a community. This activity showed how a disease could spread through a population of people without anyone knowing that they were infected or that they were passing on the disease. You and your classmates were given a cup of clear liquid—all the cups looked the same. You were instructed by your teacher to go around the room and exchange liquid with your class mates. Your teacher then added a second solution as a test to your cup of liquid after you shared with a number of your classmates. Your teacher's solution was able to identify if your solution had been contaminated by a "germ" that was present in one of the other cups. By mixing solutions, a disease had been spread through the classroom. As you interacted with more and more of your classmates during the simulation, more and more students got sick. This activity was a simulation on how a disease could be spread through a community—in this case your class was the community.

1. What did you learn form this activity?

_____

_____

_____

2.In the activity, did you get sick? (as shown by a change of color of your solution—clear to pink) If you got sick, how did you feel once you found out you were sick? How did you react??

_____

_____

_____

How many students in your class weren't sick? Why didn't they get sick?

_____

_____

_____

3. Were you able to track the spread of disease around the room? Why or why not?

_____

_____

_____

Epidemiology is a field of medicine that deals with
the tracking and controlling of disease in a population.

Tracking a disease

There are people who do figure out why and how a disease spreads in a group of people. These people are called epidemiologists. They figure out the start of the disease and how people are connected through disease.

Epidemiologists (people who track the spread of disease as a job) noticed that during the winter, more people seem to come down with the flu. One reason for this increase is that people stay inside more and come in contact with each other more often. Additionally, the germs are also more trapped inside because windows and doors are not open as often.

Now its your turn to be the epidemiologist. Try to identify the initial disease carrier in the two stories below.

During winter break, Lucy went over to Bill's house to listen to music. Later, Jose went to Lucy's house. The next day Jose was sick. Bill was not sick. The day after Jose got sick, Lucy got sick as well.

1. Use the story above to answer the question. Who introduced the disease to this group? If you draw out all the different interactions that the three people had, identifying the start of the disease will be easier. Explain your response. (Use the back of the paper if you need additional space.)

_____
_____
_____
_____
_____
_____

Carl went to Justin's house for dinner. Carl had dinner with Justin and Tatina. After dinner, Carl went back to his house and watched TV with his Mom. Tatina went to Keishla's house. The next day Keishla and Carl meet for lunch. That night, Carl, his Mom and Keishla were all sick.

2. Use the story above to answer the question. Who introduced the disease to this group of friends? Explain your response. (Use the back of the paper if you need additional space.)

_____
_____
_____
_____
_____
_____