

**Teaching Science in Elementary School:Using Field Trips to Support Guided Inquiry
Lessons**

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Masters of Science Teaching

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Overview

This study looks at the ability of second graders to generate and evaluate scientific evidence before and after learning to control initially uncontrolled variables presented in a scientific question. This study tested the effectiveness of a four day classroom lesson on the control for variable strategy, followed by a field trip in which the students use the control for variable strategy to conduct an experiment. My hypothesis before I started the study was that field trips are instructionally significant to science learning. I think students gain more from a field trip than classroom instruction alone. Furthermore this field experience for children is an important part of scientific inquiry development, and will help prepare elementary students to be successful in learning the scientific method at the middle and high school level.

Purpose

This study was inspired from my experience with having the job of presenting a local Science Fair, which begins with the assignment to students to come up with a project. I found that the middle school students had no prior knowledge in which to begin the process of scientific investigation. Why were these students not prepared by our elementary schools to participate in something that is sponsored by our middle and high schools?

The United States hosts the International Science and Engineering Fair (ISEF) each year in the spring. The Science Fair is for middle and high school students. Successful science fair projects are inventive and require a great deal of ingenuity on the part of the students. Students need to demonstrate thinking skills, not just knowledge about the topic (Raber, 2006). The ISEF is a great way to find the next generation of scientists that will be needed to understand the growing problems and solutions of our world. However, in order for students to be competitive in a science fair, they must first learn how to set up a valid experiment, control for variables and

make meaningful inferences. These skills are also important for scientific reasoning in school as well as everyday problem solving. The acquisition and transfer of the control for variable strategy is an important skill in scientific reasoning and cognitive development. (Chen and Klahr, 1999) The control for variable strategy is where the student can explore a multivariable system and isolate one variable at a time to determine the effect each one has on a system in order to make a valid conclusion.

Background

The National Academy of Sciences report, “Taking Science to School: Learning and Teaching Science in Grades K-8”, (Duschl, Schweingruber, & Shouse, 2007), was commissioned to answer three questions: (1) How is science learned, and are there critical stages in children’s development of scientific concepts? (2) How should science be taught in K-8 classrooms? (3) What research is needed to increase understanding about how students learn the scientific method and ultimately, scientific knowledge? From this study the committee developed a framework for proficiency in science that differs from the current national science standards which are seen as “a mile wide and an inch deep” (Section 9, pg. 3). They identify four fundamental strands of learning:

1. Know, use, and interpret scientific explanations of the natural world.
2. Generate and evaluate scientific evidence and explanations.
3. Understand the nature and development of scientific knowledge.
4. Participate productively in scientific practices and discourse.

It is recommended that these four strands be taught simultaneously in order for students to develop proficiency in science. Some conclusions that the National Academy of Sciences research reported are:

- Children come to school with powerful resources on which science investigation can build.
- Young children can learn to explain natural phenomena, design and conduct empirical investigations, and engage in meaningful evidence-based argumentation.
- Science learning depends on both the student's prior knowledge and experiences.
- Students learn science by actively engaging in the practice of applying the scientific method.
- Students need carefully structured experiences, instructional support from teachers, and opportunities for sustained engagement with the same set of ideas over weeks, months, and even years.
- Children must engage in genuine science investigations where scientific intuition can be discovered.

I embraced these conclusions and wanted to contribute data on how children learn best to generate and evaluate scientific evidence, (Strand 2). For this study I developed a model that provides adult assistance for young students to discover and experiment in a structured, meaningful way. The field experience part of my study supports learning science as practice by modeling the steps of generating and evaluating scientific evidence. Jerome Brunner called this adult assistance scaffolding, (Woolfolk, 1995).

According to Duschl, Schweingruber, & Shouse, (2007), "Scaffolding is ongoing guidance provided to students as they perform a task, which facilitates performance and learning. Scaffolding can be viewed as the additional support around a core (baseline) version of a task to make it more tractable and useful for learning. Scaffolding is always defined relative to some assumed baseline version of the task." (p. 272). This support can be in the form of clues,

reminders, encouragement, breaking the problem down into steps, providing an example, or anything else that allows the student to grow as an independent learner.

I developed a field experiment based on a current scientific experiment studying some aspects of global warming. I think my climate change experiment set up with one adult assisting each group of four students, allows the student to engage in a genuine science investigation where the out come is discovered. The field experience would end up being a demonstration without the scaffolding. Scaffolding elementary school children's engagement in authentic inquiry, over which they have increasing control, is an effective way to develop children's understanding of science as a way of knowing (Metz, 2004). A benefit to starting at such a young age with guided inquiry or guided discovery learning is that children will learn how to become independent inquirers and be able to participate in a free inquiry learning environment.

Participants

This research was conducted at two different schools in the Socorro Public School District with three different second grade classes. The experimental group was 16 students with an average age of 8 years 4 months; (range 7 years 9 months to 8 years 10 months). They went to school at Cottonwood Valley Charter School (CVCS), which is for kindergarten through the eighth grade. This group received two treatments, the four day control for variables lesson followed by two field trips where they set up an experiment that used the control for variable strategy. The students did not design the experiment; they were guided through a proper experimental set up, and guided through the steps of collecting and evaluating data.

The control group consisted of two classes, both with 14 students. Class one had an average age of 8 years 5 months; (range 7 years 11 months to 9 years 7 months), class two had an average age of 8 years 3 months; (range 7 years 10 months to 8 years 8 months). They went

to school at Parkview Elementary which is for kindergarten through third grade. These students received only the four day lesson on controlling for variables. These two classes had significant differences; class one was for English as Second Language (ESL) students, and the teacher did not follow a science curriculum during the year, instead she concentrated on reading and math instruction. Class two did science lessons throughout the year and had a Science Fair month where they set up different experiments in the classroom as a whole class.

Materials

I made most of the materials used for both the classroom lessons and the field experiment. I drew illustrations for the pre- and post-test questions in order for young students to pay attention to the question being asked.

For the control for variable lesson, I made ten ramps that were 6" X 20", out of ¼" plywood. Each ramp had 1" sides so the ball would not fall off. I cut two notches, 1½" and 7½" from the top, so a piece of ¼" plywood could slide in to adjust the ramp for length. The stand for the ramp was made from 2X6 dimension lumber cut in two pieces to make an "L". The long side was 6 inches, which creates an 18 degree angle, and the short side 3 ½ inches, which creates a 10 degree angle. I used indoor/outdoor carpet cut in pieces to fit the ramps so they could easily be changed.

For the field experiment I made five 2X4X2 foot boxes with 2X4 dimension lumber. Two were covered in clear plastic, two were covered in black plastic, and one was wood covered in aluminized mylar. (See appendix C for additional materials.)

Procedure

I gave 44 second grade students in three different classes a pre-test that consisted of eight questions. Four of the questions asked the student if the example of an experimental design was a

good test or a bad test for providing the capability to organize their observations in order to develop an explanation of phenomena, and why. Four of the questions asked what an experiment was testing that was already in progress, and how they knew that. After 4, one hour lessons on generating and evaluating scientific evidence, I gave the same students a post-test that had the same type of questions, but applied to a new scenario. Both pre- and post-test questions were read out loud to the students, and then they responded orally as I wrote down their answers.

I got the ideas for the questions from an example of a question that Chen and Klahr (1999) used in their control for variable study, and a question that Tschirgi (1980) used to study children's understanding of scientific inquiry. I also got some ideas from a National Energy Education Department (NEED) Project unit on experimental design methods, and others I just created. All the questions were about domains that were familiar to second grade students, i.e. plants, animals, sinking objects, boxes in the sun, balloons, popsicles, ice cubes, model airplanes and boats, and baking. The experimental situations in the questions contained only thermometers, rulers, and balances as measuring tools.

Control Group Treatment

To teach the control of variables in the classroom, I was guided by the methods used by Chen and Klahr (1999). This study addressed how children acquire a domain-general processing strategy (Control for Variables Strategy) and generalize it across various contexts. They used three different domains; springs, ramps, and sinking objects, a question was presented for each. Their test subjects were second, third and fourth grade students from a private school in Pennsylvania. Their study concluded that when provided with explicit training within domains,

combined with probe questions, children were able to learn and transfer the basic strategy for designing unconfounded experiments that were capable of obtaining valid conclusions.

In order to compare with the results of my own experimental project, I began with one of the three domains that Chen and Klahr used in their study. I used the ramp question: What factors determine how far a ball will roll down a ramp? Is it the length of the ramp, the angle of the ramp, or the surface of the ramp?

My lesson (see appendix A) was designed to help the students adopt a scientific method to learn how natural systems behave. In the activities, students learned to isolate variables to answer the ramp question. This lesson was completed in four, one hour periods. The first day the students explored and discovered how the ramps work and developed measurement strategies. The next two days the students conducted the experiment with explicit instruction, changing only one variable at a time, and gathered evidence that were designed to help answer the question. The fourth day we performed calculations and compared group results.

Experimental Group Treatment

I chose to have a climate change experiment at the Grasslands Environmental Educational Site in the Sevilleta National Wildlife Refuge (SNWR) for several reasons. First, SNWR is all set up to host educational research. Second, the project manager of the Long Term Ecological Research (LTER) was willing to give me a tour of all the experiments that are set up in the grasslands section. I wanted to piggyback on something that already existed as scientifically important, just simplified for second grade students. I wanted to show the students an on-going experiment to add authenticity to their own study.

I got the idea of climate change boxes from an experiment that the project manager of the LTER at Sevilletta showed me that is using box like plots to see how interactions of nighttime warming, winter precipitation, and Nitrogen deposition affects shrub establishment and the abundance of dominant grasses in grassland ecosystems.

Before going to SNWR, the educational outreach coordinator talked to the students about what a National Wildlife Refuge was, and how Sevilletta came to be. The next day, the class discussed what they knew about global warming and climate change. Next, I handed out a paper with the experimental question on it: How does imposing the green house effect, or darkness, and reduced airflow for two weeks affect the air temperature, soil temperature and soil moisture in a grassland ecosystem? Is there any change in the plants? Then each student wrote a hypothesis about what they thought would happen inside their box.

On two different days the class went to the Grassland Environmental Education Site in the SNWR. The first day the project manager showed and explained to the students about the global warming experiment that is being done at SNWR. The students then went down the road and set up a short term experiment that I designed to test for effects of global warming on the plants and soil. The experiment was such that the students only needed thermometers, rulers, and balances to measure material with.

The students measured the air and soil temperature, and took a soil sample and plant leaf samples to take back to a geology lab at New Mexico Tech, where they weighed their samples and placed them in an oven. The students came back to the geology lab to remove them from the oven and weigh the soil and plant leaves again. This part of the field experience gave the students an opportunity to use scientific tools in a real science lab, again adding authenticity to their experiment. With the data recorded in each team's science journals, each student made a

bar graph (see appendix D) showing the changes in air and soil temperature and soil and plant moisture during the two week period.

Results

Table 1

Group	<u>Class Average Score</u>		<u>Evaluation Questions</u>		<u>Generation Questions</u>	
	Pre	Post	Pre	Post	Pre	Post
Experimental	38%	56%	48%	66%	28%	46%
Control	35%	46%	42%	48%	29%	44%
Control ESL	21%	48%	23%	46%	20%	50%

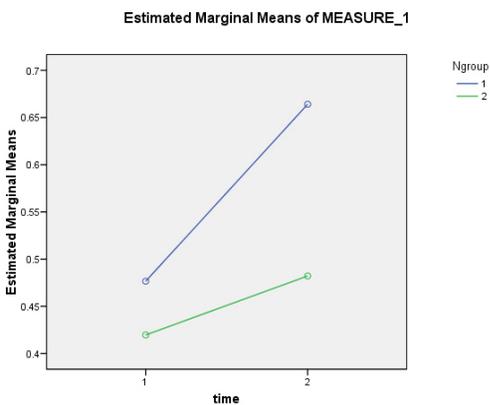
I evaluated the pre and post test scores, each question was given a score of 0, .5, or 1 except the multiple choice questions were 0 or 1 point. A ½ point was given for saying if it was a good or bad test, and another ½ point was given for identifying the variables. Table 1 shows in the pre-test there is a big difference between classes from the same school depending if a science curriculum was taught. The two classes that had science in the curriculum performed similarly on the pre-test. All three groups had more difficulty generating scientific evidence compared to evaluating scientific evidence.

To avoid a confounded study, I will compare the two groups that were equivalent on the pre-test to analyze to test my hypothesis. Pre and post test scores were compared between groups in mixed-design Analyses of Variance (ANOVAs) for both Evaluation and Generation. The main effects in each ANOVA were Group (Between-subjects measure: Experimental/Control) and Time (Within-subjects measure: Pre/Post). In addition to the two main effects, the interaction of Group and Time was also

examined statistically for significance. When the interaction term was significant at an alpha level of .05 (indicating that the change from pre to post was not the same in both groups), pairwise comparisons were carried out to determine the significance and characteristics of the change. Statistical significance levels were adjusted using the Bonferroni procedure.

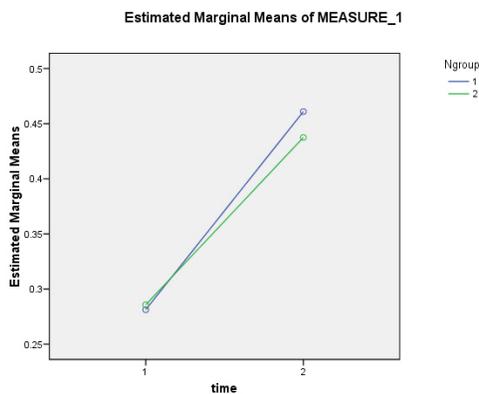
Neither interaction was statistically significant for Generation or Evaluation. I did find that there was a significant difference over Time for Evaluation ($p=.019$), with students performing better on the posttest than on the pretest. Graph 1 does show that the slope for Group 1, the experimental group, shows more change from pretest to posttest (.19 vs. .06). The lack of significance is probably due to lack of statistical power (inadequate sample size). Similarly, Graph 2 shows both groups changed significantly from pretest to posttest on Generation ($p=.004$), with Group 1 changing slightly more than Group 2 (although the differences between the two groups in the amount of change, .18 and .15, respectively, are clearly not substantial in this case).

Graph 1



Evaluating scientific evidence

Graph 2



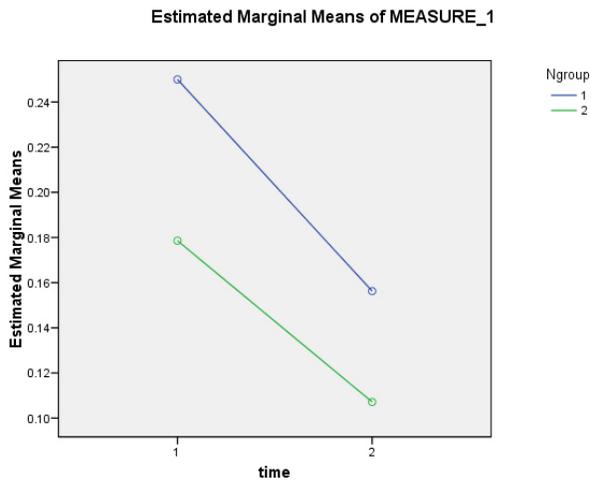
Generating scientific evidence

Some answers on the pre and post test demonstrate that young children will think *with* their theories rather than about them (Kuhn, 2002). These types of answers could provide insight into the development of scientific thinking skills; so I evaluated the results of the students' responses to the test questions based upon how they answered them. The responses could be divided into three categories.

One category of responses was those that had an interesting view of the natural world, for example water being weak or strong. Another category of responses concerned the outcome of the experiment, not whether the experimental set up would determine a valid outcome. The third category of responses was based on prior knowledge and preexisting theories of the natural world rather than evaluation of the experiment according to scientific method and evidence. The student went beyond the scope of the question, bringing in external information for a reason to the question. For example an experiment to test how far a model airplane would fly was a bad test, because somebody might walk by and get hit by it.

Three separate ANOVAs were carried out to compare responses pre and post for both groups. No differences were found between groups and no significant interactions were found. The tests were not significant for either interesting viewpoints or outcomes. However, the number of inventive answers decreased significantly in both groups from pre to post, (graph 3). The post test scores were significantly negatively correlated between the frequency of inventive answers and the post test scores on the ability to generate and evaluate scientific evidence, (graph 1 and 2).

Graph 3



Use of inventive answers on pre and post test

Discussion

Because of the differences in test conditions that evolved from a learning experience on my part, my experimental program conducted in this study can best be considered a pilot study. The space that was available for the control for variables lesson was very different between the two school sites. There was significant difference in the pre and post testing conditions also.

At the charter school, we were in the classroom where the desks had to be moved each time. The room was not wide enough, so the student groups bumped into each other, and it was not long enough for the ball to roll off the high angle ramp. At Parkview Elementary there was a science room that I set up completely before the students arrived, and the room was big enough.

The students were tested individually at both schools, but there were many distractions at the charter school compared to a quiet space at Parkview Elementary. I think this might have helped the control group more than the charter school.

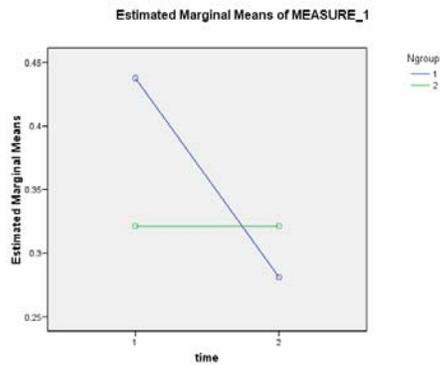
I think my hypothesis was supported only for evaluating and not generating scientific evidence because I designed the field experience part of the experiment the students did not, they

collected data and evaluated what happened during the two week experiment. I think the improvement of both the control group and the experimental group on generating scientific evidence shows that the lessons on controlling for variables increased the students' scientific thinking skills.

The ESL class had the most to gain and responded very well to a hands-on guided discovery lesson. They were able to perform as well on the post test as the other class from Parkview that had science all year with just 4 hours of instruction. They demonstrated a better understanding about generating scientific experiments on the post test than the other two groups. One reason for this result may have also been that the ESL class was my third time facilitating the control for variables lesson. From the other two groups I learned some techniques that were more effective. Because of my experience, I expanded my Control for Variables Lesson plan (see appendix A) for five days instead of four.

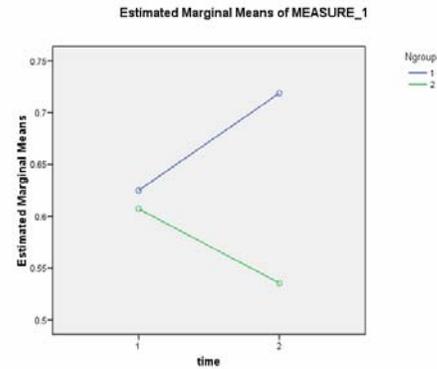
Another problem with the validity of this study is that I was the only one to grade the tests. The results might be different if an independent team had graded them. Also, the pre- and post- test needs further evaluation to determine that the questions were of equal difficulty and not ambiguous in nature. In particular, graphs 4 and 5 shows that the generating scientific evidence pre and post test question about model airplanes and sail boats, and the evaluating scientific evidence pre and post test question about growing plants, might not have been effective. (See appendix E for questions)

Graph 4



Pre: Yucca in soil – Post: Trees by the pond

Graph 5



Pre: Airplanes –Post: Sail boats

Conclusion

From this pilot program I have learned several things. Each student group has a parent leader, and you have to train the parents before the field trip. I noticed some parents doing all the work and not recognizing teachable moments.

I also learned that second graders math skills are not as good as their scientific inquiry skills. They have not learned how to divide, so they can not average the trials in the control for variables lesson, and they cannot calculate the soil moisture on the field trip.

I think that accurate data is hard for a second grader to get; partly due to observation skills development, attention span, and muscular development. With that in mind the proper scaffolding at this age is even more important.

I believe getting young students out in the field for a hands-on, authentic scientific experience, is important in order for them to want to, and be enthusiastic towards learning science when they are older. This enthusiasm for science may be the best thing one can foster. I think a further study would show evidence that field trips are an important component in science

education. Science is fun, and the scientific method can yield useful insights into the underpinnings of nature.

Acknowledgements

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I had assistance with experimental design, statistical analysis, and interpretation by Patricia Jones, Ph.D., of the Research Computing Group (Retired) at the Center for Computing and Research Technology, University of Arizona. Analyses were carried out using SPSS 15.0 (Chicago, IL: SPSS, Inc.).

The field experiment was made possible by The Sevilletta National Wildlife Refuge and support from Mike Friggens, the Long Term Ecological Research project manager. He took me on a tour of the ongoing experiments in the grassland ecosystem, and so generously gave a tour of one of the experiments to the second grade class. Kimberly King-Wrenn, the education outreach coordinator, guided me through the educational permit process and came to the second grade classroom to give a presentation about wildlife refuges.

I had an undergraduate psychology student, Joe Aranda, doing an independent study under Dr. Samuels, working with me. He helped me build the ramps and boxes, and he assisted in the classroom lessons. He also helped set up and test the field experiment, and was out in the field with the students. And finally, I could not have completed my study without Valerie Stuart, Diana Hooper, and Mela Straley, the second grade teachers who were willing to participate in my research project.

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Appendix A

CONTROL FOR VARIABLES LESSON

GRADE LEVEL: Elementary, [If the students have not learned division, only one trial should be done so you don't have to average the trials]

OBJECTIVE: To give students an opportunity to discover and practice strategies for working in a team, measuring, and recording data. Students will learn how to generate and evaluate scientific evidence.

DURATION: Five days, one hour each day

MATERIALS: A large empty room. Ten ramps that adjust for angle, length, and surface. Twenty 100 cm tape measures, selection of different types of balls, (rubber bouncy balls, golf balls, ping pong balls, soft practice golf balls), five science journals and pencils.

Day 1 –

Goals: Work as a team

Develop good measuring strategies

Practice recording data

Students split into five groups of 4 students each. Each group is given 2 ramps, 4 tape measures, and 2 pieces of carpet, and a selection of different types of balls, and a science journal.

The question is introduced: What factors determine how far a ball will roll down a ramp? Is it the length of the ramp, the angle of the ramp, or the surface of the ramp? To solve this problem each group will need a system to measure how far the ball rolled and a method to record the data.

The students will spend the time playing with and discovering how to manipulate the ramps, having races, measuring and recording the results, predicting who will win. During the last 10 minutes, gather as a whole class and discuss what worked well and what didn't.

Day 2- [Before class, set up 100 cm markers in a straight line on the floor with tape from each group's starting point, you will need at least 5 markers, up to 500 cm.]

Introduce some good measuring strategies that they will need to use for a fair test, in order to have a valid conclusion.

- Ramps have to be in the same place for every trial
- You have to measure from the same side of the ball for every trial
- Use the 100 cm markings instead of multiple tape measures, (this was probably brought up in day one's discussion of what didn't work well)
- The ball has to roll without human interruption
- When the ball curves, make a perpendicular line to the straight line of hundred cm marks to measure

Pair the students up with a ramp to practice using the prescribed measuring strategies.

Day 3 – [Before class make 5 copies each of the data sheets cut into fourths.]

Vocabulary: Variable

Trials

Evidence

Present the question again: What factors determine how far a ball will roll down a ramp? Is it the length of the ramp, the angle of the ramp, or the surface of the ramp? The class will learn in order to get a valid result they can only vary one thing at a time. From a list on the board:

Angle of ramp -	High	Low
Length of ramp -	Long	Short
Surface of ramp -	Wood	Carpet

The class will choose one thing to change; the groups will glue a pre-made data set up in their science journal. Roll the *practice golf balls*, and record the distance traveled, repeat this set two more times. Before starting, remind the groups about working as a team, and that each person has a job to do: setting up the ramps and rolling the balls, measuring, recording the data, returning the balls to the ramp. During the last 10 minutes, gather as a whole class and discuss what worked well and what didn't.

Day 4 –

Vocabulary: Independent Variable
Dependent Variable
Control

Before breaking into groups, remind students of the first three goals, review day 3 vocabulary, use the data sheets to go over today's vocabulary.

The class will continue the process for the other two variables; all five groups doing the exact same set up, gluing on the appropriate pre-made data chart in their science journal. During the last 10 minutes, gather as a whole class and discuss what worked well and what didn't.

Day 5 – [Before class copy their data sheets so every one in the group has one.]

Vocabulary: Data
Bar Graph
Average

Hand out a data sheet for each student and teach how to calculate the average distance the ball rolled on each ramp and determine the difference. Repeat this for each data sheet.

Have each group report the final numbers for each independent variable on the chalk board. Compare group results, analyze the results and make a conclusion. You now have evidence to answer the question with. Have the students graph their results.

As a class discuss the importance of multiple trials and accurate measuring. Ask the class what kind of science they were doing the last five days. Have the class brainstorm a list of the different types of science i.e. Biology, Geology etc. Conclude that this ramp lesson was teaching them how to do science, no matter which kind they are interested in.

Assessment –

Each student, one at a time, will set up the two ramps any way they want, and tell you what they are measuring with their set up. The student will tell you what the independent variable is, and what the two variables they are controlling.

Possible Extensions

There are four different ways to set up the ramps to control for one variable, so there are twelve possible configurations in all. Maybe switch the groups around, repeat and see if you get the same results no matter how you set it up.

Using the same list from Day 3, add another variable:

The type of ball – Golf Rubber

The students working in their groups will practice setting up an experiment, making their own data table, and collecting data, like they did on day 2, to control for variables, but now having four variables.

Appendix B

Example of two possibilities of student data sheet

Controls Surface Rug Length Short	Independent Variable	Angle of Ramp	
		High	Low
		Dependant Variable	
	Trial	Distance Rolled	
	1		
	2		
	3		
	Total		
	Average		
	Difference in Average Distance		

Controls Angle High Length Short	Independent Variable	Surface of Ramp	
		Rug	Wood
		Dependant Variable	
	Trial	Distance Rolled	
	1		
	2		
	3		
	Total		
	Average		
	Difference in Average Distance		

Appendix C

CLIMATE CHANGE EXPERIMENT

Topic

Climate change

Question

How does imposing darkness and reduced airflow for two weeks affect the air temperature, soil temperature and soil moisture in a grassland ecosystem? Is there any change in the plants?

How does imposing the greenhouse effect and reduced airflow for two weeks affect the air temperature, soil temperature and soil moisture in a grass land ecosystem? Is there any change in the plants?

How do imposing darkness and reflecting the sun's rays, and reduced airflow for two weeks affect the air temperature, soil temperature and soil moisture in a grassland ecosystem? Is there any change in the plants?

Hypothesis: What you think the answer to the question is; what changes you expect to see.

Procedure: How you do the test

- The five student teams need to decide on the same type of plants to put their climate change box over; and where to place their boxes.
- Before placing the box, take measurements of air temperature, and soil temperature, (stick the soil thermometer in the soil 8 cm down, leave it there for 10 minutes)
- Scrape the ground surface clear and then using the little shovel, take a 1 cup soil sample from an 8 cm depth, put it in a zip lock baggie and close right away

- Cut off plant leaves and put it in a zip lock baggie and close right away
- Write down and draw observations of plants and ground covering inside the boxed area
- Take a picture of what the box is going to cover (optional)
- Place the box over the plants so no air gets under the box, secure with two grade stakes and screws
- Label the box with team names, and label the soil/plant samples
- Back in class, weigh the soil and plants, then put into an oven at 20 degrees C over night, weigh them again and calculate moisture content
- Return to the boxes two weeks later at the same time of day, and take the same measurements and write down observations

Materials: What you need to do the test

A 2X4X2 box covered in black plastic, or clear plastic, or foil

2 grade stakes

Drill, 2 screws, hammer

Soil thermometer

Air thermometer

Measuring cup

Little shovel with depth markings

Zip lock baggies

Permanent markers

Science journal

Pencil or pen, scissors

Camera (optional)

Balance

Little foil baking dishes for the soil and plant samples

Oven

Controls: The things that stay the same

The type of plants

Soil type

Time of climate change treatment

Independent Variable: The things you change in the experiment

Reduced air flow

Amount of light

Amount of heat

Dependent Variable: The things that change because you changed something in the experiment

Air temperature

Soil temperature

Soil moisture

Plant growth

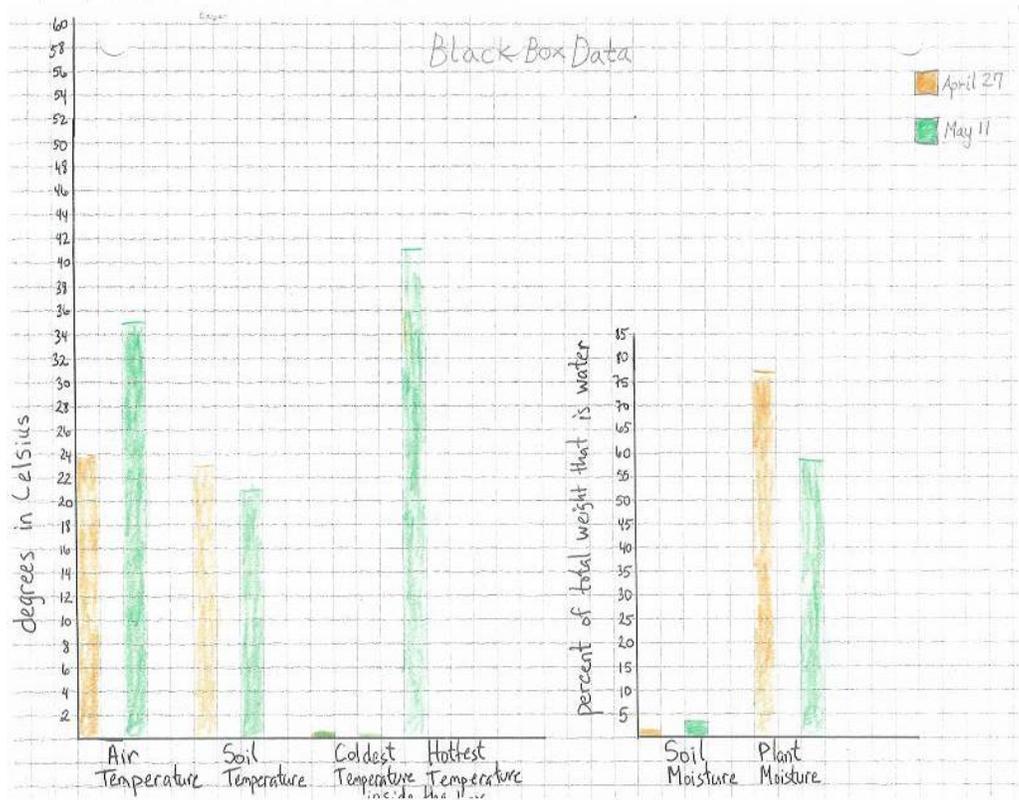
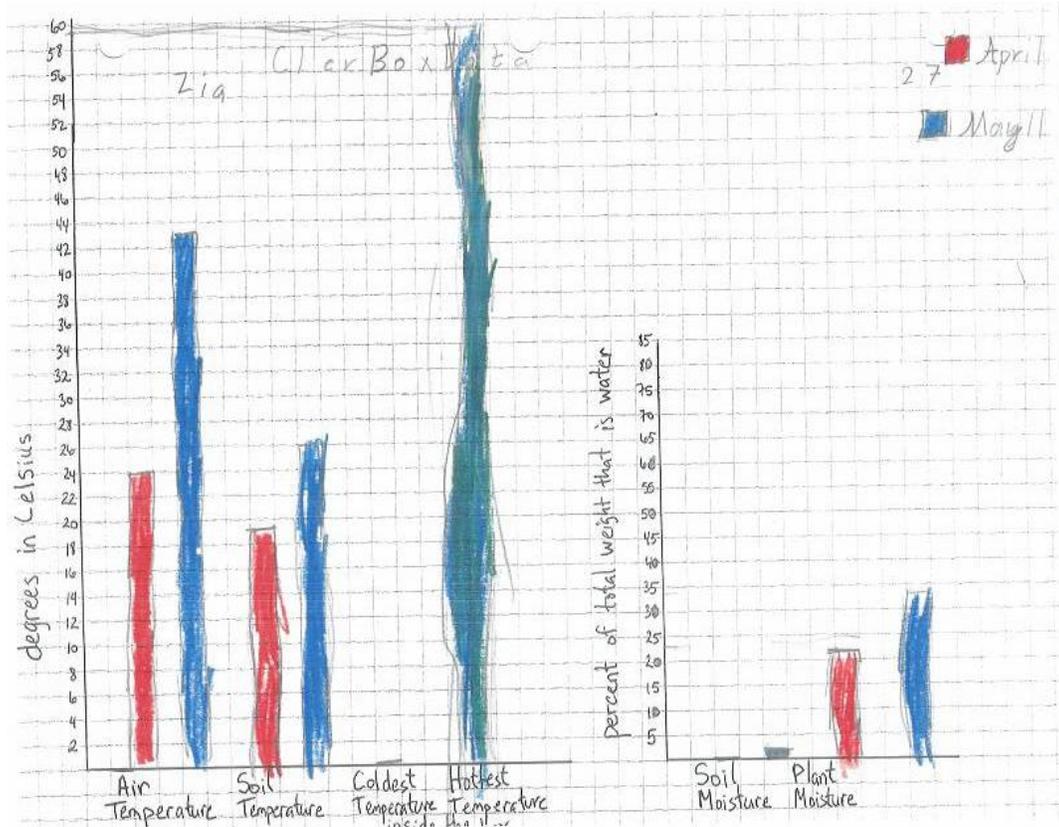
Data: What happens in the experiment, what you are measuring

Make a chart with three columns and five rows, record the air and soil temperatures and the soil and plant moisture from both days. Make a double bar graph comparing the two days. Compare the boxes to each other.

Analysis/Conclusion: What your data shows

Write a paragraph describing the changes and why you think they happened, was your hypothesis correct.

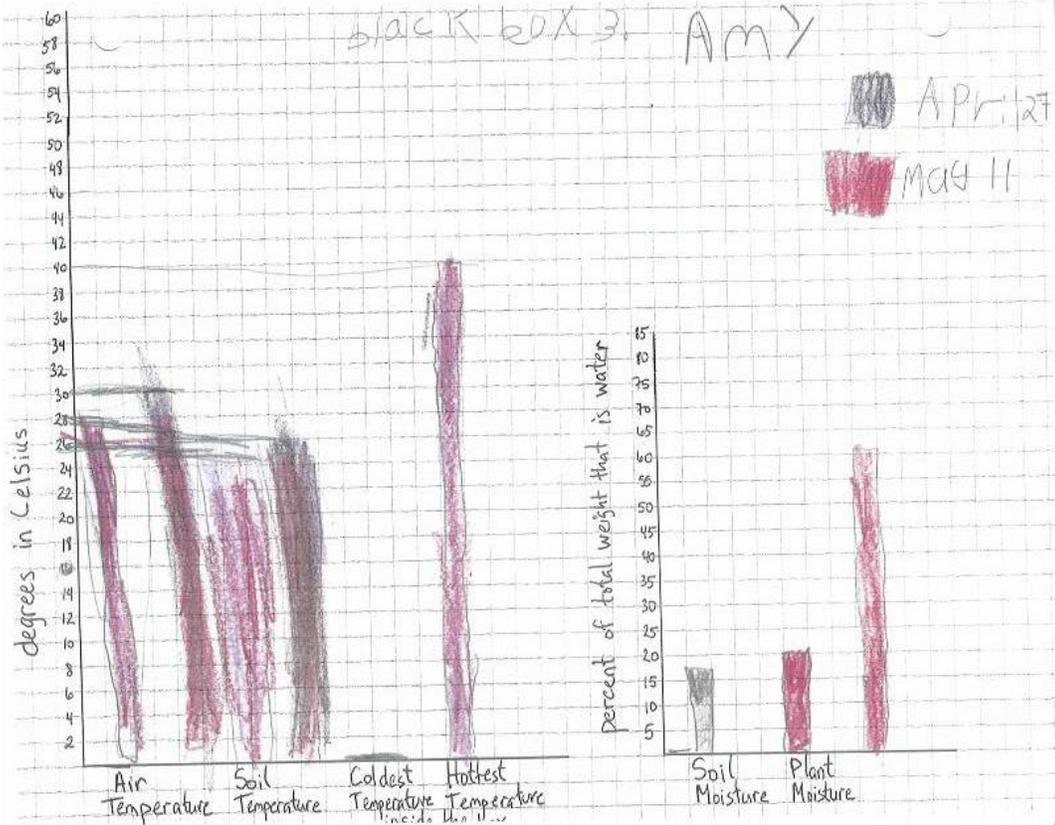
Appendix D

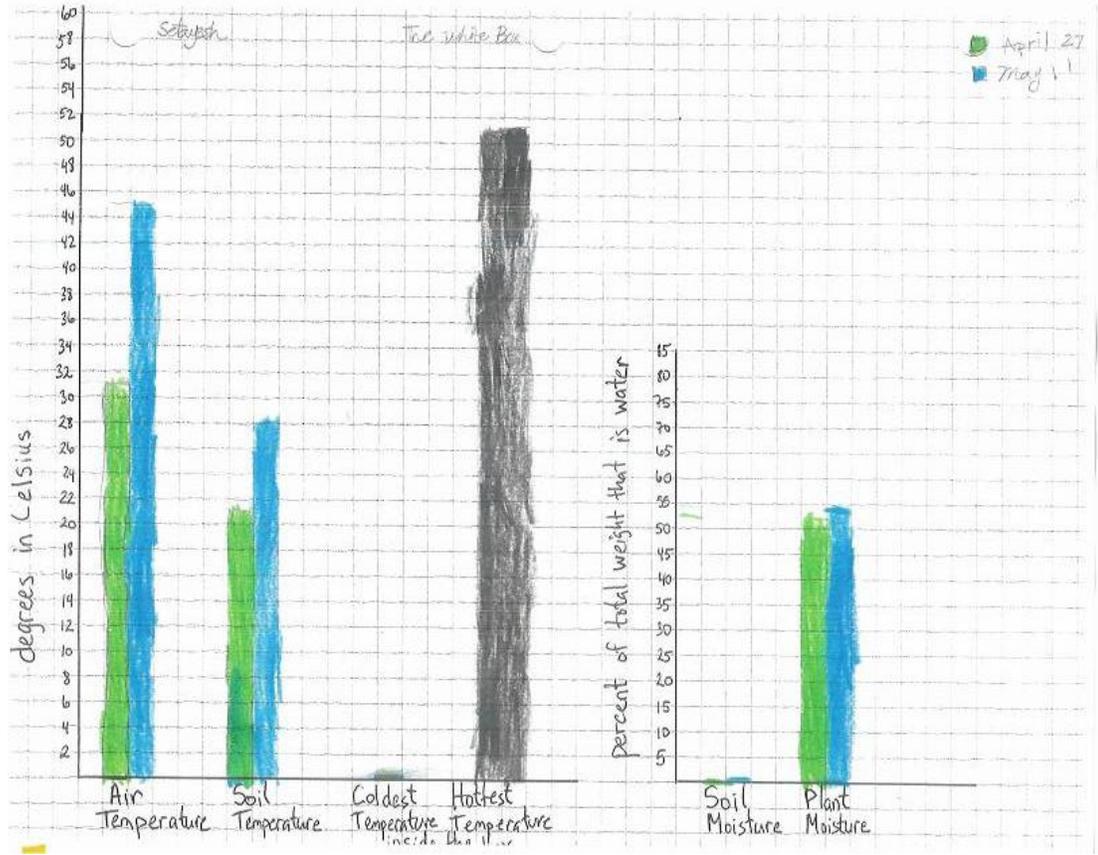


black box 3, Amy

APR 27

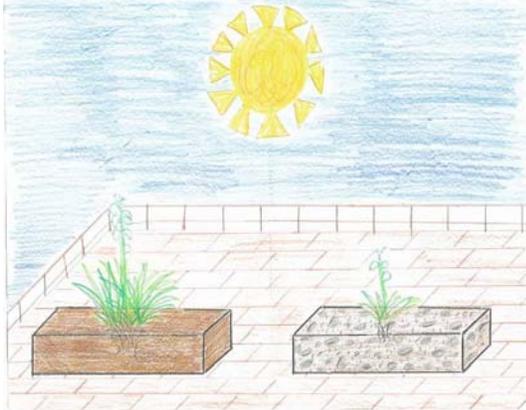
MAY 11



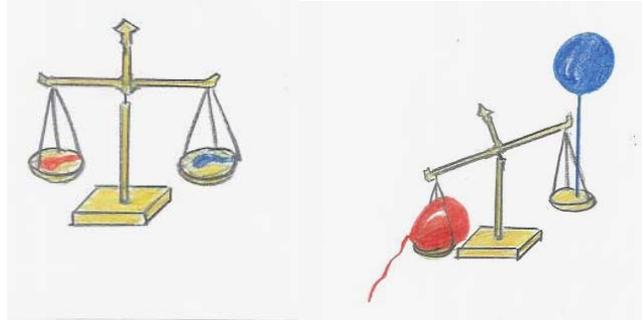


- B. Bake another cake using sugar, but the same margarine and the same white flour.
- C. Bake another cake changing all the ingredients.

PRE-TEST QUESTIONS ON EVALUATING SCIENTIFIC EVIDENCE



These two yucca plants were planted at the same time, in the same amount of dirt taken from different places. What is being tested in this experiment? How do you know?



This experiment gives evidence that:



This student is putting three ice trays that are the same size in the freezer at the same time, one has orange juice, one has cherry juice, and the third has grape juice. She checks on them every five minutes. What is this experiment testing? or why not?

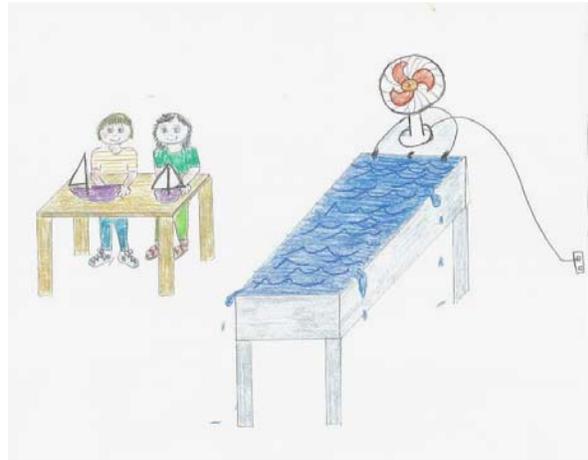
Since the one Angora rabbit jumped higher than the one Sable rabbit, the student concludes that the one has cherry juice, and the other has grape juice. She checks on them every five minutes. What is this experiment testing? Is this a good or bad conclusion? Why experiment testing?

- A. Which ice cube tastes better
- B. Which juice freezes first
- C. Which juice melts first
- D. How cold the freezer is

POST-TEST QUESTIONS ON GENERATING SCIENTIFIC EVIDENCE



This experimental design is set up to test what determines the temperature in the box. Is it the size of box, color of lid, or what the box is made out of? For the first trial, two cardboard boxes that are the same size were placed in the sun at the same time. One box has a black lid and the other box has a gray lid. Is this a good test or a bad test? Why or why not?



These students are experimenting to see what makes a boat go faster, the size of the boat or the size of the sail.

One student made a big wooden boat with one sail, and the other student made a small wooden boat with two sails. Is their experiment a good test or a bad test? Why or why not?



This student wants to find out how the color of light might affect plant growth. Do plants grow better under green light or red light? He is using the same type of seeds, in the same size pots. Each plant gets $\frac{1}{4}$ cup of water. Is this experimental design a good test or a bad test? Why or why not?

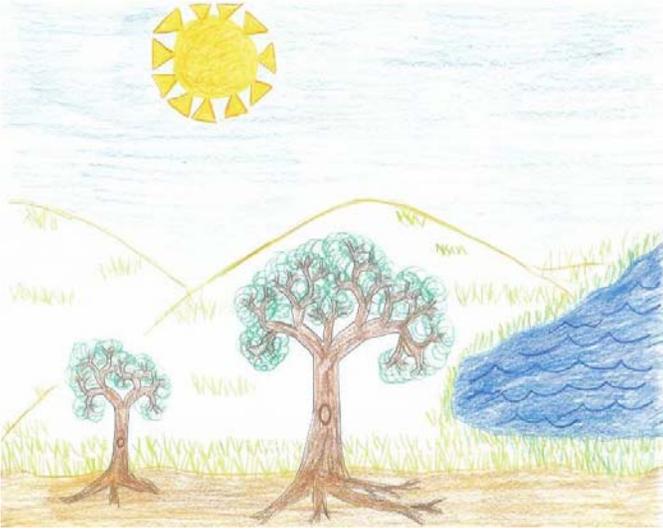


These students baked muffins; they had a choice of using butter or oil, brown sugar or white sugar, and whole milk or skim milk. They chose butter, brown sugar, and whole milk to make the batter with. The muffins came out great; the students said it was because they used whole milk.

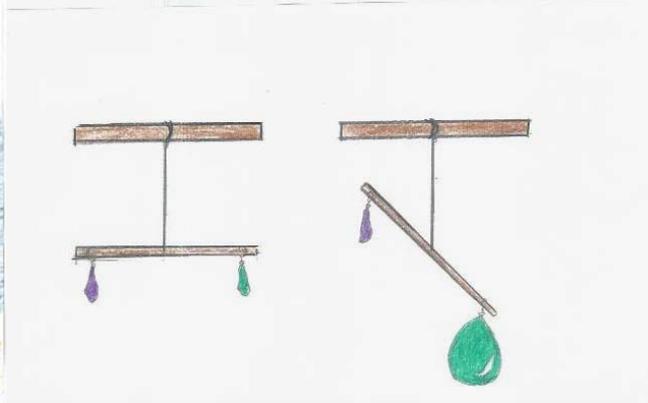
How can these students show evidence for this?

- Bake more muffins changing all the ingredients.
- Bake more muffins using the same whole milk, but change the butter to oil, and change the brown sugar to white sugar.
- Bake more muffins using skim milk, but use the same butter and the same brown sugar.

POST-TEST QUESTIONS ON EVALUATING SCIENTIFIC EVIDENCE



These two trees were planted from the same kind of seeds at the same time. One tree was planted closer to the pond. The students come back each year to measure the growth. What is being tested in this experiment? How do you know?



This experiment gives evidence that:



These two students bought the same size popsicles at the same time. One got an orange juice popsicle and one got an apple juice popsicle. They are holding them the same way and are not licking them. The students will stand in the sun until both popsicles are completely gone. What is this experiment testing?

- How hot it is outside
- Which is sweeter, orange juice or apple juice
- Which melts faster, frozen orange juice or frozen apple juice
- Which popsicle weighs more, one made from orange juice or apple juice



Since the one Green Turtle swam faster than the one Spotted Turtle, these students conclude that all Green Turtles swim faster than all Spotted Turtles. Is this a good or bad conclusion? Why or why not?

