THE GLACIAL INQUIRY:
INVESTIGATING EARTH SCIENCE INQUIRY
LESSONS IN A
FIFTH-GRADE CLASSROOM

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ABSTRACT

Elementary school is a time for children to find their identity as students, to help them prepare for their future as citizens. Helping students to read and write and develop early number sense is essential. Equally as important is capitalizing on students’ natural curiosity about the way the world works by helping them to think more scientifically. The use of inquiry science lessons in elementary schools is one of the best ways to accomplish this. It immerses students in the ways that scientists think as they explore materials and phenomena, develop wonderings, experiment, and make claims about the things that they observe based on their evidence. As I researched what inquiry science was, I developed a series of inquiry lessons about glaciers for the fifth-grade class I am student teaching in. Through discussion with the students and my own observations, I saw the power of inquiry science for students. Compared to lecture-based, note-taking science lessons, inquiry science helps students to develop long-term understanding, and increases their engagement with science overall. Through consistent use of inquiry, students may begin to overcome negative stereotypes of science as boring, and those interested in it as geeks or nerds. Most importantly, inquiry science can nurture student curiosity instead of eliminating it. Inquiry science is the most effective way to help future generations learn to appreciate science and understand how scientific claims are generated, which allows them to make informed decisions regarding what they believe. This is an essential aspect in a world faced by challenges that only science can solve.
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Chapter 1

Why Inquiry Science?

Rationale

In today’s competitive society, the performance of our nation’s schools is incredibly important. As our society becomes more invested in technology, we need to understand more about science and technology to make informed, effective choices and decisions in order to be productive citizens. The National Assessment of Educational Progress has been charting the performance of students in different grades for the past thirty years. The 2000 results from science show that approximately two thirds of students are at or above basic, and only approximately one third are at or above proficient. It is important to compare this statistic to international students evaluated in the 2004 Third International Mathematics and Science Study (TIMSS), involving students in forty-one nations in fourth and eighth grade and their final year of secondary school. This study found that in fourth grade, American students were slightly above the international average, but by eighth grade and even more by the final year of secondary school, the United States’ students’ ranking weakened noticeably (National Science Board, 2004).

“America’s shameful glut of scientifically-illiterate younger citizens is easily traced to our elementary schools” (MacMahan & Stevens, 1993). It is not fair to put the entire blame on elementary schools as students have opportunities to learn science in grades K-16, and science education at each grade level needs attention. There are some challenges that face elementary schools in particular. Maybe the largest is that elementary teachers are prepared as generalists, they teach every subject. In my personal degree program, we are given a base in educational theory, and a smattering of general education courses. We only have one class covering science teaching methods, and very few required for science content knowledge. If teachers are expected to be proficient in every subject, they must do a lot of research on their own time.

Another stumbling block to elementary science has been the belief that young children are not developmentally ready to think scientifically. However, new research has shown that children are capable
of “surprisingly sophisticated ways of thinking about the natural world based on direct experiences with the physical environment” (Michaels, Shouse, & Schweingruber, 2008, p. 6). If teachers expect great science thinking from their students and provide the materials and expertise necessary, then those students will rise to meet the occasion.

If the United States is to continue to compete on a world stage, then the educational system needs to continue to adapt, especially in elementary schools. If students are given a solid base of knowledge in primary grades, both in subject matter and in understanding of how science works, then, assuming quality instruction, the secondary school courses will be able to teach more advanced topics. For instance, if a child leaves elementary school with a basic knowledge of the systems in their body, then in middle and high school they will be able to learn more about how the systems function individually and as an entire organism. Then by graduation, the student will be comfortable with that information and college work and medical school will be able to build on that prior knowledge. And future doctors or nurses are not the only ones who need a solid understanding of how the human body works. Elementary students who learn about their body systems in school will also know how to better take care of themselves and lead healthy lives.

The need for a shift in elementary education is becoming more and more apparent, and both state and national standards are shifting to reflect that fact. In terms of science instruction in particular, more and more people are focusing on inquiry as an effective instruction tool.

The aim of inquiry science is for children to develop their ideas about the natural world. Understanding grows as children work collaboratively with each other, with the teacher, and with materials, in situations structured to contribute to their ideas or hypotheses and their questions. (Hall, 1998, p. 1)

Inquiry science is based on the idea that children who are able to direct their own research questions and knowledge acquisition learn the material better than from a teacher directed lecture or activity. In inquiry lessons, students are given materials to manipulate and explore, they ask research questions that they want to learn more about or the teacher or curriculum poses a question for the students, they develop experiments to answer those questions, and discuss the results in order to determine what they learned. The teacher’s role is to guide and assist, not to direct the students to specific learning. However, the teacher must also be invested in the content. The teacher needs to be able to support the students as they learn, and this can only be accomplished through the help of a knowledgeable teacher. In addition to knowledge of
the content, teachers need to be comfortable talking about the way science works as they use evidence that is found to support claims. A teacher who is knowledgeable about the content, the structure, and the students in the class will be most effective in helping students discover truths about the world they live in.

In the example above about elementary students learning about their body systems, inquiry lessons could be adapted that are not very demanding in terms of materials or space. Students can explore their body systems through careful observations of how their own bodies move and react to outside stimuli as they investigate a driving question and develop evidence-based claims. Students can explore basic physics principles such as gravity and force through manipulation of magnets, balls, trucks, blocks, or a myriad of other common objects. The teacher can provide a general focus of learning depending on the materials provided for the students. Inquiry lessons can be developed from watching plants grow, making waves in water tanks, or making waves and wiggles with Slinkys®. The key in these science lessons is to help the students place emphasis on seeing evidence and discovering an explanation for that evidence.

Studying earth science is much more challenging for a teacher who wants to use an inquiry-based lesson. Students are not able to manipulate volcanoes or earthquakes to see how they work. The fun of making a volcano erupt using baking soda and vinegar is exciting and looks like an eruption, but real volcanoes are not full of cooking ingredients. Most schools cannot afford to send their students to the desert or rainforest to explore different ecosystems. Developing lessons about these scientific topics can be intimidating to teachers because the topics are not immediately tangible.

A scientific topic that is in the press daily and often on the public’s mind is global climate change. Again, this is a concept that would be challenging for students and teachers to investigate without support. One of the indicators that help scientists to realize and understand what is happening with climate is the behavior of glaciers. These huge, slow-moving bodies of ice have been shrinking. Core samples taken from glaciers help scientists learn what the climate has done in the past and what it is capable of in the future. While they are far from being the only indicators of global climate change, they are a big part. This is a very important topic in today’s society and therefore one that is important for students to explore. The children climbing on the monkey bars at recess today are likely the ones who will come up with solutions to take care of our planet in the future. Learning about glaciers and how they behave is one way to give
children a stepping-stone. Glaciers are more tangible than a concept such as global climate change. Students can grasp what a glacier is and how it moves. Then they can build on that understanding and learn about how glaciers have helped humans understand how the climate behaves. They will be able to add more and more to their body of knowledge if they have a place to start that they can understand.

Inquiry science is a very effective way to help students learn how science works and engage in authentic science experiences. Students are more engaged when they are actively investigating a wondering. The question becomes, how can a teacher cover a virtually intangible topic such as glaciers and global warming in an elementary classroom? The purpose of this project is to answer this question and more by selecting a topic and deciding on an approach and continuing to a description of how the project was implemented and how teachers and students reacted to it. The hope is that others will be convinced of the importance of this approach and be inspired to use it in their own classrooms. The first step, in a country that is putting more and more focus on performance on standardized tests, is fitting an inquiry lesson into state and national standards.
Chapter 2

What Questions Might Inquiry Answer?

Wonderings and sub-questions

Main Wondering

How do science inquiry lessons affect fifth-graders’ curiosity?

Sub-questions

- What defines inquiry lessons?

- Are students able to retain information and write and talk about it weeks after the inquiry lesson is over?

- What is student curiosity, and how can it be observed?

- What are students’ preconceptions about science?

- Can negative conceptions about science be changed through inquiry?
Chapter 3

How Does Inquiry Align with Standards?

In today’s educational climate, many groups hold educators to high standards. National and state standards, district requirements, and student and parent expectations all place restrictions upon teachers. Through personal experience as a student teaching intern, it is clear that testing also restricts teachers in terms of the content and subjects that they are able to teach. Fifth grade elementary teachers give multiple district assessments throughout the year in math, reading, and writing. Pennsylvania System of School Assessment (PSSA) tests are administered in the same areas. With the emphasis created by these tests placed on these three basic subjects, time devoted to social studies and science in the classroom has been restricted. This has been expressed to me by a number of teachers in the school district. The challenge of the educator is to teach science and social studies in the most efficient manner that will benefit the students while aligning with state and national standards in these subjects. For science, inquiry can be a very efficient method for this, and it is a method that also effectively supports state and national standards (National Research Council, 2000).

Inquiry science can appear in many forms in an elementary classroom, but the overarching goal is for students to “engage in many of the same activities and thinking processes as scientists who are seeking to expand human knowledge of the natural world” (National Research Council, 2000, p. 1). The National Science Education Standards provides guidelines for inquiry use in classrooms, broken down by age level. For students in grades K-4, inquiry should help students “focus on the processes of doing investigations…develop the ability to ask scientific questions, investigate aspects of the world around them, and use their observations to construct reasonable explanations for the questions posed” (National Research Council, 1996, p. 121). As the students grow older, inquiry can begin to take them further in their understanding of science. In grades 5-8, the National Science Education Standards state the students “can begin to recognize the relationship between explanation and evidence…the experiments and investigations students conduct become experiences that shape and modify their background knowledge” (National...
“The aim of inquiry science is for children to develop their ideas about the natural world. Understanding grows as children work collaboratively with each other, with the teacher, and with materials, in situations structured to contribute to their ideas or hypotheses and their questions” (Hall, 1998). This aim can be met through a variety of ways. In full inquiry lessons, students are given materials and time to explore them. As they do, they record wonderings or questions that arise from the phenomena. The teacher then facilitates discussion about these wonderings, and assists as students create experiments to answer the wonderings and questions. At the end of the experimentation phase, students articulate claims based on the evidence they found. Through the process, the teacher is an integral figure that helps the students be successful scientists.

Due to time and material constraints, guided inquiry lessons are common, in which students are presented with a wondering or question by the teacher. The teacher also provides the expert knowledge base necessary to help students effectively investigate the phenomena. If materials are unavailable, the teacher can supplement videos, pictures, websites, or descriptions of experiments, allowing students to develop claims based on what the teacher has told them. The teacher also must be comfortable with the process of inquiry, and the scientific rules and norms that guide the process.

What inquiry is not is a free-for-all where students simply play with materials while teachers stand back and watch. It is not a time where students are expected to simply absorb knowledge or stumble upon robust scientific understandings. Instead, it is a process that is carefully developed by the teacher and class together. Students need to feel as though they are scientists. This can be developed through class science talks where the teacher and students talk about what they have seen, using scientific idea and norms of participation. Once students are in the mindset of scientists, they will see the materials as tools, not as toys. This helps them take the next step of using those materials to develop experiments.

Students are not expected to magically know the scientific ideas and phenomena that have taken centuries to develop. The students are not reading the information from a textbook, which would be faster in teaching time, but they are seeing the evidence right before their eyes, which in general means that the understandings developed are more meaningful than if they were simply memorized.
Inquiry is the cornerstone of the National Science Education Standards. These standards “spell out a vision of science education that will make scientific literacy for all a reality in the 21st century. They point toward a destination and provide a roadmap for how to get there” (National Research Council, 1996, p. ix). The National Science Education Standards cover science teaching standards, standards for professional development for teachers of science, science content standards, science education program standards, and science education system standards. Inquiry is woven into the majority of all of these, not only as a process, but also as content knowledge that guides students to an understanding of the rules that govern scientists and scientific discoveries. The first science teaching standard states, “Teachers of science plan an inquiry-based science program for their students” (National Research Council, 1996, p. 30). In the content standards, each grade level division begins with a section covering science as inquiry before covering the subject areas such as physical, life, and earth sciences (National Research Council, 1996).

Educators must adhere to state standards as well, in addition to standards developed by the school district. The states each interpreted the national standards in their own ways, as do local districts. Teachers must create a lesson plan based on all three. Although in theory, a teacher who uses only the district-level standards would also be fulfilling the requirements of all as state and district standards are often reiterations of national.

Pennsylvania standards rely on inquiry as much as the national standards do. Pennsylvania is one of the few states to have two standards relating to science – Science and Technology and Environment and Ecology. In the Science and Technology section, there are eight areas that are included. The last six cover biological, physical, and earth sciences, technology education, technological devices, and science, technology, and human endeavors. The first idea is unifying themes that exist through all scientific disciplines. The second is Inquiry and Design. This is the only section of the Pennsylvania standards that specifically mentions inquiry, arguably because the Pennsylvania standards focus on what the students will be able to do or know, whereas the national standards also guide what the teacher will be doing to teach science. This difference is the reason we do not see inquiry as frequently in the Pennsylvania state standards. However, when the Pennsylvania standards are read in the context of the national standards, the most obvious solution seems to be to teach science subjects according to the state, using inquiry methods as
recommended at the national level (Pennsylvania Department of Education, 2002).

Through inquiry, educators can teach science more effectively. Teachers have expressed the opinion that inquiry helps students connect to the big ideas in a more meaningful way, and so have a better learning experience. It can be taught in a variety of ways, allowing teachers to adapt the lesson to the restrictions they have based on time and materials. Inquiry aligns with national and state standards, which means that it is appropriate to use in today’s test-driven education society.
Chapter 4

Why Study Glaciers?

Studying glaciers in a fifth-grade classroom in central Pennsylvania may not seem like the most appropriate choice initially. Educators often try to use topics that the students can personally relate to, so that the students are able to make more connections and learn easier. However, glaciers are an interesting way to introduce a topic that affects all of us, not matter where we live.

Glaciers are an invaluable tool for learning about our world’s past climate. Through studying landforms, scientists can tell where glaciers were in past ice ages. By looking at glaciers today, it is evident that glaciers are melting rapidly. This has been documented in numerous pictures of glaciers taken in different years from the same location. They show a massive retreat of the majority of the world’s glaciers, indicating that the average global temperature is increasing (USGS, 2009b).

Glaciers and ice sheets also hold information about the past climate. Scientists are able to drill ice cores in ice sheets of Antarctica and Greenland. Through these cores, scientists can look at debris and air bubbles that are trapped in the ice. The air bubbles contain samples of the air from thousands of years ago, allowing scientists to see how it has changed over time. Ash from volcanic eruptions gets trapped in layers of ice, which helps date the sample. Pollen is also in the ice, which is an indicator of what plants were growing at the time. By combining all of these data, scientists can get a fairly accurate picture of what the climate was like through the history of that ice core (Alley, 2002). That information is helping scientists to see the mechanism for climate change, a change in the composition of greenhouse gases.

Greenhouse gases are necessary to our survival on earth. Without them, the earth would get too cold for anything to live on it. These gases provide the insulation we need to survive. They do this by reflecting some of the sun’s energy and trapping some of it in the earth’s atmosphere. This trapped energy bounces back and forth between the gases and the earth and creates the warmth that we need to survive. Some of these greenhouse gases include carbon dioxide, water, and methane (USGS, 2009a).

The ice cores have provided data showing how the amounts of these greenhouse gases have changed.
over time. When put on a graph, it becomes clear that an increase in carbon dioxide and other gases coincides directly with the increase in the average global temperature. A large number of scientists came together to study the available information about global climate change and to try to reach a consensus about it. This gathering, the Intergovernmental Panel on Climate Change, has concluded, “Warming of the climate system is unequivocal” (IPCC, 2007, p. 30) and that “Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004” (IPCC, 2007, p. 36). Together, this means that humans are affecting the current changes that are warming our world up.

Through informal discussion with my students, I found that they have heard the term “global warming” numerous times, but they did not know what it meant. Through discussion, I was able to answer a lot of the students’ questions. Then, the class as a whole began brainstorming things that they could do to help. The first step to solving any problem, even one as large as global warming, is understanding what the problem is. While the students most likely do not have personal experience with glaciers, they do have personal experience with the term global warming. It is important for them to begin to understand this problem now, so that as they continue through their lives, they do not harbor misconceptions about it.
Chapter 5

How Can Curiosity Be Measured?

In today’s world, children often receive near-constant stimulation from television, video games, computers, mp3 players, and a host of other sources. In fact, one study from the 1980’s found that “by ages three and four, [children] are averaging four hours a day of viewing, and this figure is increasing” (Singer, 1983, p. 815). The article goes on to say that children spend more time sitting in front of the TV than they do in school. With all of the entertainment available at students’ fingertips, I have found that it can be hard to capture their attention in the classroom. Even more challenging is arousing curiosity in students. Being curious is one of the prerequisites for being successful as a scientist. If a person does not look around and ask WHY something is the way it is, that person will not then go out and explore the question and try to answer it.

One of the goals of an outstanding science teacher must be to help students open their minds to become curious about the world around them. If this is not accomplished, then science lessons will be just another exercise for the students. Inquiry lessons provide a setting for students to continue to develop the curiosity, which they enter early grades with, about how the world works.

Determining how student curiosity changes can only be accomplished after a method for measuring curiosity is determined. It is not possible to see into students’ heads to determine how curious they are. There is no machine that will measure curiosity levels. It is necessary to find a piece of observable evidence to evaluate the non-observable trait of curiosity. That evidence can be questions. If a student is not curious about what is happening, they will not take the time or energy to express questions. On the other hand, if they see things that make them wonder, then the students will ask questions to find out what the phenomena is happening.

In my fifth grade classroom, questions are divided into two categories, “thin” and “thick.” Thin questions are ones that can be answered with one word, or questions in which the answer can be found
spelled out in a book or dictionary. Thick questions involve making inferences or thinking beyond what we see right in front of us. If students are asking thin questions, then they are not thinking deeply about the topic, and instead are just scratching the surface. Thick questions show students who are turning information over and over in their heads, thinking about it in new ways and pushing further.

As quoted by John Barell, a middle school teacher “observed that a “good question opens doors. It demands more than a yes or no answer” (Barell, 2003, p. 61). Barell goes on to say that good questions “[open] doors to new ideas, novel ways of looking at a situation…a good question is one that is transcendent, one that helps us move beyond the immediate data or experience” (Barell, 2003, p. 61). Taking this a step further, students who are really curious about a topic and are thinking very hard about it will ask just the sorts of questions that Barell is talking about. Therefore, by analyzing the questions that students ask, it is possible to determine how curious they are about that subject. If, during the course of a lesson, the number of “thick” questions increases, then the students are becoming comfortable with the material presented and more curious about it as they strive to learn more.

Teaches also promote curiosity through the selection of lessons. Students seem to become more curious about something if it is something that they can personally experience. To capitalize on this, teachers can use real-world problems. I have taught a few math lessons where a new planet was invented, complete with animals of varying heights. The students were graphing how fast these make-believe animals grew and describing their rates of growth. Through the activity, the students were not excited about completing it, and their attention wandered easily form one topic to another. However, when I posed the same type of problem to the students using the heights of their classmates, the students got into a lively discussion. By using a real-world problem, I was able to engage the students more and pique their curiosity.

Similarly, students become involved in a problem if they see discrepant events. For instance, why does one plant grow while another one dies? Students that see that something is not the way it is supposed to be tend to ask questions to try and learn why that discrepancy occurs. Posing such problems is another way that teachers can foster curiosity in their students.
Chapter 6

Where Does This Investigation Take Place?
Teaching Context and Data Sources

My lessons were taught in my fifth-grade classroom at Gray’s Woods Elementary School, in the State College Area School District. This district is located in the center of Pennsylvania and is in that location because of the Pennsylvania State University. Many of the students in the district have parents who are employees of the university in some fashion, as professors, staff, or other employees.

Gray’s Woods students are mainly from upper middle class families, but there are students who receive free and reduced price lunches. In my fifth-grade classroom, there is one student who is in this program. We have three students who receive learning support and five who are in the learning enrichment program.

The data that was used for the purpose of this research came from multiple sources. The first source was personal observation of my fifth-grade class as a whole. I did not focus on any individual students for this, but I kept notes about how the entire class reacted to the lessons I taught. I also talked informally with other mentor teachers and interns in the PDS program. I received a lot of information from my SCI ED 458 class, both in terms of what inquiry science is and in effective ways to incorporate inquiry science into the classroom. Finally, I used expert literature discussing the idea of inquiry science in elementary schools.

After collecting data from a variety of sources, I began the process of analyzing it. Expert literature was used to support the ideas about what inquiry is and how it can be implemented in classrooms. The notes from general observations were color-coded and analyzed based on different topics: how student curiosity was affected, the questions that students asked, student engagement levels, and student perception of science. My notes taken from conversations with mentors and PDAs were similarly analyzed. A more detailed description of the process follows in later chapters.
Chapter 7

How Can Inquiry be Investigated?
Data Collection and Analysis Procedures

The driving question behind my research was: how can I help fifth grade students become more curious about the world they live in? My background research began when a member of the Center for Remote Sensing of Ice Sheet (CReSIS) approached me and talked with me about creating a method for CReSIS to provide outreach to local elementary schools. I then began to think about how I could teach elementary students about glaciers in a fun and engaging way. My original thought of a presentation with lots of pictures was thrown out the window when I began to research the practice of using inquiry science in schools.

Initially, inquiry science seemed to me to be an inconceivable amount of work for teachers. Gathering materials, supervising as students ran loose in the classroom playing with the materials, and cleaning up at the end all combined to make me think that there would be no way I would use this strategy in a classroom. However, as I began to research more, I realized that my impressions were very wrong. As described in previous sections, inquiry does not mean that students are running loose, expected to just magically accumulate or discover the information they need. Instead, the teacher guides the students through the process so that authentic learning can occur. The more I researched an inquiry approach, the more it seemed to be the perfect way to help students become excited about learning science and being scientists.

Once I felt that, through my background research, I had a working understanding of the inquiry method, the next step was to develop lesson plans. This process also fulfilled requirements for SCI ED 458, in which we were asked to develop a series of three science lessons on one topic, using inquiry-driven lessons (Appendix A). I began the process by listing the things that I wanted students to learn about glaciers. I began with the assumption that the students would have minimal prior knowledge of glaciers. So my first goal was for students to know what glaciers are, where they can be found, and how they move.
After students understand that, I wanted them to know how scientists study glaciers. I think it is important for students to see what adult scientists do when they work. I have experienced the misconceptions that students have that scientists always work inside with glass beakers and test tubes while wearing white lab coats. By showing the students footage and pictures of glaciologists, working outside in the field, those misconceptions could be at least challenged, if not overturned. Finally, it is important to connect the topic of glaciers to students’ everyday lives so that they will have more of a reason to care. Therefore, students should know the role that glaciers play in indicating global warming, what global warming is, and how it affects their every day lives.

The next challenge was to find a way to make glaciers fit into an inquiry science lesson. While inquiry can have many forms, one requirement is that students need to be able to interact with phenomena, and living in central Pennsylvania, we do not have a glacier in our backyard to interact with. Consequently, I had to find a way to model glaciers for students so they would be able to explore glaciers from their classroom. Luckily, CReSIS had some wonderful ideas on their website. One of these was glacier goo, a substance made from a mixture of water, glue, and borax powder. This substance emulates the way a glacier slowly moves downhill, or when placed in a pile it spreads out from the center the way a glacier does. This gave me a way for students to explore glaciers without seeing one.

Trying to let students explore the way scientists study glaciers was another challenge, as they again do not have access to glaciers or to core samples. In trying to think of ways to model ice cores, I began to create a homemade one by freezing water in layers, each layer being either clear water or containing a drop of blue food coloring. This allowed me to model the way ice cores can be counted the way tree rings can. In glaciers, summer ice is a different color than winter ice because of the temperature at which it freezes. Scientists use this to determine how old the glacier is. Dust, ash, and other things trapped in the ice can also help in dating. For instance, if a big volcano is known to have erupted during a particular year, scientists can see ash in the ice and confirm their own counting of the ice layers. While students would not actively drill an ice core, they could look at a model of one and practice counting layers and see if there were any debris in the layers.

Another thing that scientists do to study glaciers is to observe them directly over a period of time,
as well as land where glaciers have been in the past. To demonstrate this in the classroom, I decided to bring a series of pictures in to the classroom. Some of the pictures were sets showing a glacier moving over time, both forward and backwards. Some were valleys and rocks that were shaped by glaciers. And some were glaciers moving to the ocean and falling apart into icebergs.

Finding an activity to help students learn about global warming and the greenhouse effect was not as challenging. The CReSIS website was again helpful with the idea to model greenhouses by simply placing two thermometers in the sun or under a lamp, one in a plastic Ziploc bag and one left out, and comparing the two temperatures. The students will see that the thermometer in the bag registers a warmer temperature than the one in the open air, demonstrating the way our atmosphere traps heat energy close to the earth. The greenhouse effect is normal and necessary for life to survive on the earth. The problem has come when too much heat is trapped due to changes in the composition of the atmosphere. This is known as global warming. Signs of global warming have been seen in glaciers and ice sheets around the world, including glaciers that are retreating, and trapped air bubbles in the ice that have shown scientists how carbon dioxide levels in the atmosphere have changed throughout time.

Having the luxury of being in a fifth-grade, self-contained classroom for my student teaching experience, and having a flexible mentor teacher who allowed me to teach science lessons that were not in the curriculum, I was able to support student learning for these lessons. As my process of writing lesson plans began, I first assessed students for their prior knowledge about glaciers. I used a quick draw and write (Appendix B) where I was looking at whether students knew that glaciers were huge masses of ice that move over time. In general, that my class believed glaciers were the same as icebergs, and they knew that global warming made glaciers shrink. This was the beginning of the SCI ED 458 assignment, and the information I gathered from this was used only for that class, and not as a data source for this thesis.

Once I had determined the engaging activities I would do to help students meet the goals I set, I began to write lesson plans. As they evolved I went from one broad lesson to three more focused lessons, each one centered around one of the big ideas I wanted students to understand. Those big ideas were, what is a glacier, how do glaciers move, what methods do scientists use to study glaciers, and why do glaciers matter to us. I made sure that my lessons met a number of Pennsylvania state standards. They were also
designed to be inquiry-driven lessons. Because students do not have a lot of background knowledge about glaciers, I decided to guide their exploration with a wondering instead of planning for student-generated wonderings. The lessons also offered ways to differentiate for students (Appendix C). During the process of creating the lesson plans, I received valuable feedback from my supervisor, adviser, mentor teacher, and others involved in the Professional Development School program.

Another goal I had for my lessons was to look for ways to integrate technology. To meet this goal, and to support student learning during the lessons, I created a series of videos. The first one came with the help of Dr. Richard Alley. As a part of his undergraduate class “Geology and the National Parks” at Penn State, Dr. Alley has created musical parodies to review some of the topics. To review glaciers and global warming, he wrote “Snowflake” based on the folk song “The Fox Went Out on a Chilly Night.” My role was to add animations and images to support the song. Next, I planned three, short, videos designed to align with each lesson. They are designed so that they can be paused at places for the class to discuss a question or to engage in an investigation (Appendix D).

Once the videos were made and the lesson plans finished, the only thing left to do was teach. I was lucky enough to be loaned cold-weather Antarctica gear by Peter Burkett, so the students had a chance to try on pants, coats, and boots that scientists would wear in Antarctica. I videotaped each lesson so that I was able to review generally how the students enjoyed the lesson and how they grew as scientists. This was part of the assignment for SCI ED 458, and not a data source for the purpose of this paper.

During the lessons, students used individual science notebooks (Appendix E). Science notebooks are an integral part of science teaching. They provide a place for students to organize their wonderings, data, and claims into a place where “language, data, and experience work together to form meaning for the student” (Klentschy, 2005). I chose individual packets for two reasons. As a teacher, I wanted to be able to see how each student grew as a scientist and assess each student independently and fairly. I also believe that having packets to complete made students more responsible. We had a discussion about how scientists must record what they see and think in order for other people to believe their claims.

I decided to use individual KLEW charts as well (Hershberger, Zembal-Saul, & Starr, 2006). In a KLEW chart, students record what they think they know (K) about a subject, that is, their prior knowledge
which may or may not be correct, what they are learning (L) about that subject which is their scientific
claims, the evidence (E) that supports that learning, and what they still wonder (W). KLEW charts are
often used on the class level to guide group discussion. By documenting them in the science notebooks,
students again were placed in a situation where they had to take responsibility for their own progress.

At the end of the lessons, I was able to receive feedback from the students about whether they
liked the lessons, what they did not like about the lessons, and whether they would like me to use these
lessons with future classes. Unanimously, the class said that I should use the lessons again. Finally, the
only thing left to do was to analyze what I learned about the use of inquiry science in elementary schools.
Chapter 8

How Does Inquiry Science Affect Fifth-Grade Students?

Claims and Evidence

Claim 1:

Inquiry science lessons helped my fifth-grade students become more curious about the world around them.

Evidence:

During the course of the three glacier lessons, the questions that students asked changed dramatically, according to my own observations. On the first day, students were asking questions along the lines of ‘what is a glacier?’ and ‘what do I do?’ As the first lesson continued, students began asking questions showing that they were internalizing the basic concepts about glaciers, that they are masses of ice that move, and the students were thinking about this information in new ways. They began to ask questions such as ‘what happens if a building is in front of a glacier?’ This shows that students understood that glaciers move, and they were taking that a step further. They were becoming curious about glaciers. Just learning that glaciers move did not satisfy them.

The shift to questions indicating curiosity did not come until after the students participated in the investigation. Once students explored the materials and began to model glaciers’ movement, they began to think beyond the immediate situation. When students got to do something themselves, instead of just taking notes, their minds began to turn and their curiosity grew.
Claim 2:

Students retained more information from inquiry science lessons than from textbook or note-taking based lessons.

Evidence:

Through the course of the year in my fifth-grade classroom, I have taught both inquiry lessons and lessons in which students took notes from a power point presentation. For both types of lessons, on the day of the lesson, students were able to recall the main ideas. As time went on, however, I noticed a huge drop in information-retention from the power point lessons. On the other hand, months later students were able to talk about what they learned about glaciers from the inquiry lesson.

Through discussion with the students, I found that they also recognized that they learn more from inquiry lessons. Multiple students have told me that if they do an experiment on their own, they remember it better. Students who simply copy down information do not personally connect to it, so remembering it takes more effort. Students who perform an experiment are able to retain information longer because they have the memory of doing the experiment, and once they remember the experiment they can connect to what they learned.

Claim 3:

Students enjoy and engage in inquiry science lessons more than in note-taking lessons.

Evidence:

In talking to students, they have repeatedly told me that they do like science when they get to do a hands-on experiment, and they don’t like science when they take notes. I have also noticed this from their behavior. During lessons where we take notes, students slouch in their chairs, they complain, and they do not readily answer questions. During inquiry lessons, however, I observed that students sit up in their chairs, they look more animated, when I ask a question there are always more than five hands in the air, and I hear students talking about the lessons for days afterwards.

I have talked to a number of PDS mentor teachers and interns, across a variety of grade levels,
about their experiences with inquiry science. In every single one of the discussions, they talk about how much more engaged the students are. They have discussed examples of students who come into the year extremely opposed to science but, through the engagement in inquiry lessons, have later expressed enjoyment of the subject. I have never heard anyone express the opinion that an inquiry lesson influenced a student to not want to participate in science.

Claim 4:

Inquiry-based lessons can challenge negative conceptions of scientists.

Evidence:

When my students came in to the class in September, I talked with them about what they thought a scientist was. We did an activity called “Draw a Scientist” (Cavallo, 2007). The events described in the article were exactly mirrored by my class. Overwhelmingly they drew and talked about men with crazy white hair wearing lab coats and working with glass beakers and test tubes. In Cavallo’s article, she cites one study where she had 150 students draw their view of a scientist, and only five of them drew a female (Cavallo, 2007, p. 38). From the time I did this activity on, I made a point of calling the students scientists and talking with them about what scientists do when they work in the field. During inquiry lessons, we talked about the ways that what they were doing was very similar to what adult scientists do. When I talked with the students again about halfway through the year, every one of them had raised their opinion of science, and a handful said that they would like to be scientists when they grow up. They did not use the word boring anymore, and many of them said that they got excited when they knew there was going to be science during the day.

Cavallo discusses how, through inquiry activities where students are actively engaging in scientific investigation, students can learn to see themselves as scientists. At the end of the year, when she asks them to “Draw a Scientist” again, she hopes to see a big change in their pictures, even to the extent where students draw themselves as the scientist.
Chapter 9

Conclusion

Reflections and Future Practice

When I was five years old, I visited Mount St. Helens with my family. My family and I walked through the visitor center and watched the movie, and then we came to a tree, twisted by the eruption. As I looked at it, I asked my dad “You mean all this is for REAL?” At that moment I became a scientist. For the next few years I was convinced that I would be a volcanologist when I grew up. My parents donated books about volcanoes to the school library so that I could check them out and read them.

During the summer of 2009, I worked at Mount St. Helens. I was not working as a volcanologist, but as an interpretive park ranger. I had come to realize that, as much as I love science, the thing that I love to do is to teach other people. I am still a scientist and I will always try to learn more, but my first goal is to help other children feel the curiosity and wonder that I did as a five year old, staring up at a dead tree.

During this research, I learned a number of things about inquiry science. I began by researching what inquiry science looks like in a classroom. After a suggestion, I chose to focus on teaching students about glaciers: what a glacier is, how it moves, how scientists study glaciers, and why they matter to the lives of students in Pennsylvania. I developed a series of three lessons for a fifth-grade class that answer those questions and are supported by videos that I created. After teaching the lessons, I learned a number of things. The inquiry lessons helped my students become more curious, learn more about the topic, enjoy science more, and challenge negative views of science and scientists.

For classroom teachers, inquiry is a very valuable tool. To be an effective classroom method, the teacher must be knowledgeable both in the content, and in the scientific practices that drive inquiry. In the hands of such a teacher, students will experience an authentic and interesting science lesson.

There are a few directions that research could go in from this point. First of all, a case study of a few students in which their interest levels and questions are closely examined. A systematic study of what students learn from inquiry lessons would also be valuable. Do students have a better understanding of the
big ideas, as shown through a written examination, with inquiry then they do with “traditional” lessons?

Many students do not have the chance to visit places such as Mount St. Helens. Through inquiry lessons in the classroom, we are able to provide students with interesting, informative experiences. As they perform experiences, their curiosity can grow and grow. By helping students learn that science is interesting and exciting, we are helping to equip the next generation for dealing with the challenges facing our world.
Appendix A

SCI ED 458 Teaching Inquiry Assignment

TEACHING SCIENCE AS INQUIRY PROJECT
The purpose of the teaching project is to involve you in planning and teaching a single science concept in-depth. It is expected that you use applications of technology (if appropriate). The basic idea is to support children in developing meaningful, conceptual understanding of a particular science concept through incorporating science talks, giving priority to evidence and explanation, and using approaches and instructional strategies that you have been introduced to during the semester. The project has several components that are described in detail below. *NOTE – All teaching should begin after November 3rd and be completed by Thanksgiving Break.

Target Concepts and Teaching Dates - due 9/22 (M) or 9/23 (G)
You and your mentor teacher will need to spend some time discussing which science concept will be appropriate for this project. Once you have decided on a target concept, you will need to negotiate teaching dates. The earlier you do this the better. **SCHEDULE YOUR TEACHING DATES AFTER NOV. 3rd AND BEFORE THANKSGIVING.** Your cooperating teacher already knows the schedule of science units that will be taught during the year; so don’t feel shy about discussing this project with her/him as soon as possible.

Subject Matter Research Paper (15%) - due 10/9
Developing a solid understanding of the subject matter you are teaching is an important aspect of preparing to teach. Prior to planning your lessons, you should try to learn everything you can about the concept you will be teaching. Learning should extend beyond reading about the concept to experimenting with and investigating the concept in hands-on ways. Your subject matter research should include the following components:

1. 3-4 Big Ideas related to your topic. Provide about 1/2 page description/elaboration for each idea.
2. A summary of existing research on children’s misconceptions associated with the concept.
3. Evidence of having attempted 2-3 experiments/investigations related to your topic. How did they contribute to your understanding of the subject matter? Cite references.
4. A bibliography that includes some adult level resources, some web sites, some trade books, etc. You should include a minimum of 10 resources.
5. A concept map (using Inspiration) that unpacks the components of your big ideas and relates them to one another.

Use APA style to cite references within the text.

For this assignment, you can work together in groups related by teaching topic. The first four parts posted to Taskstream, the Inspiration map needs to be emailed to instructors.

Concept Interview Paper (10%) - due 10/16
The purpose of this assignment is to help you develop a better understanding of what children think about
the concept you will be teaching. What you learn about children’s understandings, and possibly areas of
difficulty, will inform the development of your lesson plans. Your concept interview should be designed to
unpack children’s thinking about the target concept. Tasks, such as demonstrations, drawings, writing, and
experiments, are particularly useful for this purpose. Once you have designed your concept interview,
select 3-4 children from your class (with the help of your mentor teacher) based on their responses to a
whole class Quick Draw and Write task (we will explain this task in class). Be sure these children are as
different as possible in terms of their science learning, gender, and cultural background. Include the child
from the CLE case study project as one of the interviewees.

Note: We highly recommend that you record the interview using Garage Band. This should allow you to
focus on what children are saying and attempt to understand the thought processes behind the their
responses. Unless you have parental permission to use the recordings for other purposes, they should be
deleted after you have analyzed them.

Your write-up for this project should include the following components:

1. Identify the concept(s) you were assessing. Describe the whole class draw/write task and summarize
   your findings. Provide evidence for the claims you make about students’ ideas (writing and
drawing samples are appropriate).
2. Brief profile of each student you interviewed (use pseudonyms). Include a rationale for how they
   were selected to participate.
3. Describe your individual interview task. Summarize your findings. Provide evidence for the claims
   you make about students’ ideas (quotes form interviews are appropriate).
5. How will you use this information? Describe in detail how your knowledge of children’s
   experiences, ideas, and misconceptions will guide your planning (i.e. what activities and materials
   you will choose to use and why, how you will sequence your lessons and why, what assessments
   you will design and for what purposes, etc…)

Note: Whenever possible, you should integrate existing research findings about children’s misconceptions.

You are encouraged to work in topic groups on this assignment. When working in groups, each member
should conduct their own interviews independently, and then pool results with the group.

Lesson Plans and Planning Meetings (10%) – Lesson plans due at second meeting
Planning is a critical phase of the instructional process. It is where your understanding of the science
content, research on children’s conceptions of the content, and instructional strategies come together. By
the time you actually write your lesson plans, you will have been engaged in the planning process for
several weeks. A lesson plan template is available on TaskStream.

The first of two meetings with your instructor will take place early in the planning process. This is a
brainstorming session of sorts, and will involve a discussion of the science you intend to teach, students’
likely areas of difficulty, possible representations of the content, and other important considerations for
planning. It is expected that lesson plans will be completed and presented to your instructor at the second
meeting.

Note that the lesson plan assignment does not have a specified due date. Rather, submission dates are based
on your teaching dates – more specifically, lesson plans are due at the second planning meeting.

You will need to be certain that your lesson plans address the following:

• What are the big science ideas you plan to address in your teaching?
• What do you want students to know and be able to do as a result of engaging in the lessons you have
  planned?
• How do you plan to engage students with the big ideas? What questions will you ask to engage students in predictions?
• What opportunities will students have to explore the concept (collect data)? What questions will you ask as you circulate through the class during their explorations?
• How will you help students organize their data and look for patterns?
• How will you scaffold students as they construct explanations from evidence? What specific questions will you ask to help students make explanations?
• What do you want students to know and be able to do as a result of engaging in the lessons you have planned? This should be written as “possible” claims and evidence your students might make as a result of their explorations. You might include a sample KLEW chart.
• What opportunities will you provide for students to elaborate their learning to new situations and/or elaborate on the claims they develop?
• How will you evaluate students’ learning? What kinds of evidence will you collect? What will you look for in the assessment to know that students have an understanding of the concept? How will students evaluate their own learning.

Teaching
Your classroom teaching will not be graded. Our intent is to minimize the anxiety associated with early teaching experiences and provides you with an opportunity to take risks without the fear of failure. However, you should collect evidence of children’s learning throughout your teaching, especially at the end, by using the same whole class task you used at the beginning of your planning (or something similar but better!)

We do require that you video record your teaching for the analysis phase of the project. It is highly recommended that you do this in a digital format (mini-DV). There is at least one PDS digital video camera at each school. Other cameras are available through your school library or at PSU through Instructional Support Services in 26 Willard Building. Successful recording of your teaching is your responsibility, so be prepared. Prior to teaching you will need to: arrange for a digital video camera, purchase mini-DV media for the camera, recruit someone to tape you (mentor, PDA, intern), and check with your teacher and principal to determine whether there are students in your class who cannot be recorded during instruction. Things will go more smoothly if you practice using the camera in advance and make sure the battery is fully charged.

*Reminder – All teaching should begin on or after November 3 and be completed by Thanksgiving Break.*
Dewey once referred to reflection as the “hallmark of intelligent action” – for it is through personal and deep reflection on practice that we develop new understandings of teaching and learning. Therefore, the purpose of this aspect of the project is to learn from your teaching experiences. Watch your teaching videotape and use the analysis guidelines based on the 5-E’s to code your lessons. You should use the “note feature” to provide analysis or explanation of your choices. The evaluation section requires you to provide evidence of student learning. Evidence should come from at least two sources. These sources may include (but are not limited to) samples of student work, follow-up interviews, tape-recorded interactions from a class discussion, and an application task assessment. Be prepared to collect evidence of student learning either during or after your teaching.

Your analysis of teaching will be completed in an alternative format. You will be using Studiocode. Specific guidelines are forthcoming and we will dedicate an entire class session to the project in late November. Consider this the final exam of the course – it’s a MAJOR project! You should complete this project independently. You will need to submit all Quicktime video of all three lessons on a single DVD and the Studiocode Analysis on a second DVD.
Appendix B

Glacier Quick Draw and Write

Glacier Quick Draw and Write

I. Please draw a glacier

II. Draw the same glacier as it might look in 100 years

III. Please tell me anything else you think you know about glaciers. Use the back if you need more space!
Appendix C

Glacier Lesson Plans

GLACIER LESSON 1
Objectives: Students will be able to orally define what a glacier is.
Students will make claims about how a glacier moves and will justify their claims
with evidence from the glacier goo.

Standards: PA- Pennsylvania Academic Standards
• Subject : Science and Technology
  • Area 3.2: Inquiry and Design
    • Grade 3.2.7: Grade 7
  Standard B.: Apply process knowledge to make and interpret observations.
    • Measure materials using a variety of scales.
    • Describe relationships by making inferences and predictions.
    • Communicate, use space / time relationships, define operationally,
      raise questions, formulate hypotheses, test and experiment,
    • Design controlled experiments, recognize variables, manipulate
      variables.
    • Interpret data, formulate models, design models, and produce
      solutions.
  Standard C.: Identify and use the elements of scientific inquiry to solve
    problems.
    • Generate questions about objects, organisms and/ or events that can be
      answered through scientific investigations.
    • Evaluate the appropriateness of questions.
    • Design an investigation with limited variables to investigate a
      question.
    • Conduct a two- part experiment.
    • Judge the significance of experimental information in answering the
      question.
    • Communicate appropriate conclusions from the experiment.

• Area 3.5: Earth Sciences
  • Grade 3.5.7: Grade 7
  Standard A.: Describe earth features and processes.
    • Describe major layers of the earth.
    • Describe the processes involved in the creation of geologic features (e. g.,
      folding, faulting, volcanism, sedimentation) and that these processes
      seen today (e. g., erosion, weathering crustal plate movement) are
      similar to those in the past.
    • Describe the processes that formed Pennsylvania geologic structures
      and resources including mountains, glacial formations, water gaps and
      ridges.
    • Explain how the rock cycle affected rock formations in the state of
      Pennsylvania.
    • Distinguish between examples of rapid surface changes (e. g.,
      landslides, earthquakes) and slow surface changes (e. g., weathering).
    • Identify living plants and animals that are similar to fossil forms.
Materials:  
Student science notebooks  
“Snowflake” Video  
Glacier Video 1  
Glacier goo (In one cup, mix ¾ cp warm water with 1 cp glue, add blue food coloring if desired. In another cup, mix ½ cp warm water with 2 tsp of borax powder, stir until Borax is dissolved. Pour the Borax mix into the glue mix. Stir until a glob forms, knead for 2-3 minutes until most of the water is incorporated.)  
Cardboard slope  
Wax paper  
Aluminum foil  

Introduction:  
Begin by showing the students “The Snowflake.” This video covers all of the material that we will discuss in the course of the three lessons. After the video finishes, ask students to open their science notebook to the second page, where they will see a KLEW chart. Explain that they will be adding to these two pages over the next three lessons. Ask them to first fill in what they think they KNOW about glaciers, and if they have any WONDERINGS, add those at this time as well.

Sequence of Instruction:  
Next play the first section of Video 1. The video will prompt you to stop and discuss with the class what they think they know about glaciers. At this time, pause the video and ask students to read what they have written in the first section of the KLEW chart.  
-Now, start the video again. It will explain what a glacier is and where you can find glaciers. It will then ask you to pause the tape again and talk about what the students know about how glaciers form.  
-After this discussion, play the tape again. It will cover how glaciers form, with layers of snow falling each year. As the snow falls, the lower layers get squished and turned into ice. The video then presents two ideas for experiments – one using pancake batter and one with glacier goo. At this point, pause the video and explain to the students that they will be working with the glacier goo to try to discover how glaciers move.  
-Have a discussion with the class about what science models are and why they are important. Make sure the class knows that the materials they are about to get are tools, and they are to use them like scientists to investigate a wondering, in this case how glaciers move.  
-Pass out the materials. This works well if there are no more than 5 students in a group, and each group has their own set of materials. Give the students a few minutes to explore what they have in front of them, and then ask them to work together as a group to explore how a glacier might move.  
-As the class works, remind them to fill in the page in their notebook that fits this experiment. They should write, “How do glaciers move?” under the question. Then they need to explain or draw their experiment and talk about what they notice under evidence, and finally they should develop a claim about how glaciers move.  
-If students are struggling, suggest that they place the cardboard on a slant and see what happens if the goo is placed at the top. Or have the students pile the goo on a flat surface and see what happens. Glaciers move either by flowing downhill because of gravity, or their weight pushes the center down and the sides out.  
-At then end of the period, make sure to leave at least ten minutes for discussion. Ask groups to share the experiments that they created, the claims that they have discovered, and the evidence they have to support those claims.  
-Summarize the two ways that glaciers move, and then show the final section of Video 1.  
Conclusion: To finish the lesson, ask students to fill in what they have Learned in the KLEW chart in their notebooks, as well as the Evidence they found to support that learning.
GLACIER LESSON 2

Objectives: Students will be able to make scientific observations based on a set of pictures, and they will make claims about how glaciers have affected the landscape in the picture.

Students will discuss ways that scientists study glaciers.

Standards: PA- Pennsylvania Academic Standards

- Subject: Science and Technology
  - Area 3.2: Inquiry and Design
    - Grade 3.2.4: Grade 4
      Standard B.: Describe objects in the world using the five senses.
      • Recognize observational descriptors from each of the five senses (e.g., see- blue, feel- rough).
      • Use observations to develop a descriptive vocabulary.

    - Grade 3.2.7: Grade 7
      Standard B.: Apply process knowledge to make and interpret observations.
      • Measure materials using a variety of scales.
      • Describe relationships by making inferences and predictions.
      • Communicate, use space / time relationships, define operationally, raise questions, formulate hypotheses, test and experiment.
      • Design controlled experiments, recognize variables, manipulate variables.
      • Interpret data, formulate models, design models, and produce solutions.

Materials: Student science notebooks
Glacier Video 2
4 glacier photos
Ice core model and picture of an ice core

Introduction: Begin the lesson with a discussion of what the students learned last time about glaciers and how they move.

Sequence of Instruction: Watch the first portion of “Video 2.” In this section, students will see real glaciologists at work on an ice sheet. When prompted, pause the video and discuss with the class what they think that scientists do to study glaciers. Then watch the end of the video.

- Explain to the students that since they are not able to do research on an actual glacier, we will be getting as close as possible. They will be working in groups and rotating through 6 stations.
  - At the first station, students see two pictures of calving glaciers - one from water level and one from above.
  - At the second are two pictures of the same glacier taken 100 years apart in which the second picture shows a much smaller glacier.
  - At the third station there are again paired pictures, but this time in the recent picture the glacier is larger than the older picture.
  - At the fourth station one picture shows a glacially sculpted valley and a picture of a rock that has been scratched by a glacier.
  - Fifth is a model of an ice core and a picture of an actual ice core.
  - Finally, students get a chance to try on gear from Antarctica.

- Stress to students the importance of carefully observing the model or pictures and then creating an explanation for WHY that picture or model looks the way it does.
- At the end of the time, bring the students together to talk about the explanations they have for each station. Talk with them about how scientists use observations to help them know why the world looks the way it does. Stress the ideas that as glaciers move, they change the land, and that the layers of ice in glaciers can tell scientists what happened in the world a long time ago.

Conclusion: Give the class time to add to their KLEW charts.
GLACIER LESSON 3

Objectives: Students will write a description of how earth’s climate is changing and how glaciers provide evidence for that.

Standards: PA- Pennsylvania Academic Standards
- Subject: Science and Technology
  - Area 3.8: Science, Technology and Human Endeavors
  - Grade 3.7.7: Grade 7

Standard C.: Identify the pros and cons of applying technological and scientific solutions to address problems and the effect upon society.
  - Describe the positive and negative expected and unexpected effects of specific technological developments.
  - Describe ways technology extends and enhances human abilities.

Materials: Science notebooks
Pencil
Two thermometers
Plastic Bag
Glacier Video 3

Introduction: At the beginning of the day, set two thermometers in a sunny location, one inside a clear Ziploc bag, and one outside. Make sure they stay in sun through the course of the day. Have students record the temperature from each every hour or so. Alternatively, set up the experiment a few days in advance and collect the data over time. This way is safer, on the chance that the day of the lesson may be cloudy and you will not get good data.

Sequence of Instruction: Begin this lesson by reviewing the last two glacier lessons by discussing what a glacier is, how it moves, and how scientists study glaciers. Ask students if they have any wonderings that have arisen through the lessons.
- Watch the beginning of Video 3. Stop the video when prompted to discuss WHY scientists study glaciers.
- Watch the next section of the video. When prompted, stop the video and talk about the data you collected.
  Ask the students: What does the difference in temperature tell you? What claims can be made based on the evidence?
- Watch the rest of the video, which will discuss the important ideas of the experiment and will briefly introduce global warming.
- Have another class discussion about the ideas students already have about global warming, challenging any misconceptions students have, and talk about any questions they have.
- As students to work in their science notebooks. They will write an expository piece, as if they are talking to a friend, about what glaciers are and why they are important to an elementary student in central Pennsylvania. At the end of the session, ask for volunteers to share their writing.
- To wrap up the mini-unit, show “The Snowflake” video one more time. Encourage singing along!
Appendix D

Glacier Video Links and Descriptions

“The Snowflake”
This video is a parody of a folk song, the words written by Dr. Richard Alley for his Geology of the National Parks course, taught at the Pennsylvania State University. It is designed to be a review for the section of the course that covers glaciers and climate change. I added pictures and animations to support the lyrics.

http://www.youtube.com/watch?v=-BLW68ZB3fQ

“Glacier Video 1”
I planned this video to introduce the first of the glacier lessons. It, and the two that accompany it, are designed to be paused at various points, allowing for class discussion and exploration. This one discusses the big ideas of “what is a glacier?” and “how do glaciers move?”

http://www.youtube.com/watch?v=4vMFNKrac00

“Glacier Video 2”
To support the second lesson, this video covers the question “how do scientists study glaciers?” It begins with clips of Penn State glaciologists at work in Antarctica. It again revolves around places where the video should be paused to provide time for class discussion. It also contains a brief review of the concepts covered in the first lesson.

http://www.youtube.com/watch?v=L0A19jcyfj8

“Glacier Video 3”
This is the final video, which accompanies the final glacier lesson. Along with a review of the concepts from the first two lessons, this video talks about why scientists study glaciers. It contains a brief overview of what the greenhouse effect is, and how this relates to global warming.

http://www.youtube.com/watch?v=1joBGPq48M
Appendix E

Student Science Notebook

The Cool World of
Glaciers

By:
Vocabulary

Climate:__________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________


Glacier:__________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________


Global

Warming:__________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Greenhouse

Effect:__________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Ice Cap:________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Ice Core:_______________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Ice Sheet:_______________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________
What do you think you **KNOW** about glaciers?

What are you **LEARNING** about glaciers?
What EVIDENCE supports your learning?

What do you WONDER about glaciers?
Glacier Goo

Question:

Evidence:

Claims:
Observations

Picture Set #1

Picture Set #2
Observations

Picture Set #3

Picture Set #4
Observations

Picture Set #5

Final Claims
Ice Core Investigation

Question:

Evidence:

Claims:
Greenhouse Experiment

Question:

Evidence:

Claims:
Explain why glaciers are important to us
Write three things that you really liked about the glacier lessons.

Write three things that you would like to know more about or change about the glacier lessons.
Appendix F

Inquiry Brief

**Context:** In Gray’s Woods Elementary School, there are approximately twenty classrooms split among Kindergarten through fifth grade. The student population is drawn mainly from middle to upper class families. The school building was designed to be a greener building, and there is some focus on recycling and environmental concerns among the faculty, staff, and students.

In my self-contained fifth grade classroom, there are twenty-five students. Thirteen of these students are girls and twelve are boys. There are two Asian students, one boy and one girl, and the rest are Caucasian students. The vast majority of the students in my class come from middle to upper class families, although there are two or three students who come from a lower socio-economic status. I determined this based on observation and conversation with the students and my mentor.

While there is a wide range of ability levels in my class, the majority of the students consistently score in the A to B range across all subjects. There are five students who receive learning enrichment for math. There are a few who more consistently score lower. One of these students receives learning support for math and language arts, one receives learning support for writing, and one is in Title 1 for reading. We also have one student who has a Therapeutic Staff Support (TSS) to help him complete class work. The students’ grades correlate well with their PSSA scores from fourth grade.

State College Area School District has designed its own science curricula across the district. The implementation of science curricula is supported by a team of three Curriculum Support Teachers. The role of these individuals is to evaluate new material available for science units and to assist teachers in learning science information and effectively teaching it in classrooms. The more recent the units are, the more they focus on inquiry-based lessons. There are units that are, at this point, ten years old or more, and they are beginning to be re-evaluated now to place more of a focus on inquiry. However, there is a big push in the school to focus on writing, reading, and math, so science gets squeezed in to wherever it can. This push is not explicitly stated by the school district, but it is an opinion heard from a wide variety of classroom teachers. There is an unofficial focus from the state that directs the schools to obtain higher scores in reading, writing, and math, while the science and social studies scores are not tracked at this point.
RATIONALE:

I had the great fortune to grow up in a household where both of my parents were very interested in science and the world around them. Wherever we went, my dad would have interesting information to share with my sister and me. As I went through school, I stayed very interested in science. However, I often became frustrated with science classes because they were not interesting (mainly reading from a book), or because other students expressed the opinion that it is not cool to find science interesting. I felt this through elementary and middle school; by high school many students tended to just ignore science rather than actively antagonizing those interested in science.

By the middle of my high school experience, I knew that I would like to become a teacher. Through experiences giving Bird of Prey shows at Shaver’s Creek Environmental Center, I discovered that I loved teaching people about things that interested me. I loved to watch a child’s eyes light up when he realized how interesting these creatures are. I wanted to help more people open their eyes to the exciting and interesting world around them. In college, while also taking education classes, I took introductory science classes in a variety of disciplines, from earth science to astronomy to geography, among others. The more I read about it, the more I realized that this could be one method that would help both of my objectives.

My ultimate goal is to show students that science is fun, and that it is really exciting to learn about the world around them. We need scientists in our society to research and help manage big issues facing us. If we don’t help elementary students learn to accept and enjoy science, than how are future generations going to deal with issues such as global warming or world hunger? My idea is that inquiry science lessons can help take the first step toward this goal.
WONDERINGS:

Main Wondering:

How do science inquiry lessons affect fifth-graders’ curiosity?

Sub Questions

- What defines inquiry lessons?
- Are students able to retain information and write and talk about it weeks after the inquiry lesson is over?
- How can curiosity be observed?
- What are students’ preconceptions about science?
- Can negative conceptions about science be changed through inquiry?
**DATA COLLECTION:**

<table>
<thead>
<tr>
<th>Data I Will Collect</th>
<th>From</th>
<th>In This Way</th>
</tr>
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<tbody>
<tr>
<td>How many questions students ask at the beginnings and ends of inquiry lessons, as well as whether their questions are surface level or in-depth</td>
<td>Students</td>
<td>Watching video evidence from recorded lessons.</td>
</tr>
<tr>
<td>How much information is retained after an inquiry lesson is over</td>
<td>Students</td>
<td>Giving students a written-post test about glaciers, compared to a post test about geology topics covered in “traditional” science lessons</td>
</tr>
<tr>
<td>How do students perceive science?</td>
<td>Students</td>
<td>Interest Survey</td>
</tr>
<tr>
<td>How do students perceive science?</td>
<td>Parents</td>
<td>Survey about what their students tell the parents about science lessons.</td>
</tr>
<tr>
<td>How do teachers perceive inquiry lessons? Is inquiry useful to them? Do they see patterns in students’ enjoyment of science lessons in inquiry lessons vs. more “traditional” lessons?</td>
<td>Teachers</td>
<td>Surveys, in-person interviews</td>
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</table>
**TIMELINE:**

<table>
<thead>
<tr>
<th>Week Of:</th>
<th>What I will be doing</th>
<th>Inquiry Due Dates</th>
</tr>
</thead>
</table>
| Feb. 15  | -Survey student thoughts about science  
-Give students post-test of glacier lesson  
-Revise Inquiry Brief and Bibliography  
-Talk about extending glacier lessons with mentor | | |
| Feb. 22  | -Analyze glacier lesson video for student questioning  
-Draft survey to be given to teachers, send them out to a variety of fifth grade teachers across the district  
-Draft parent survey and send home  
-Work on teacher kit, approach a few teachers about providing feedback on it | Revised draft of brief & bib due 2/24 |
| Mar. 1   | -Complete teacher kit  
-Begin drafting second chapter of paper – what is inquiry and how it aligns with standards | | |
| Mar. 8   | -Compile teacher and parent survey results.  
-Complete second chapter of thesis  
-Begin drafting third chapter of thesis – process of developing inquiry lessons and teacher kit | | |
<table>
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<tr>
<th>Date</th>
<th>Tasks</th>
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<tbody>
<tr>
<td>Mar. 15</td>
<td>- Complete table of contents, draft academic vita, format title page</td>
</tr>
<tr>
<td></td>
<td>- Complete chapter 3</td>
</tr>
<tr>
<td></td>
<td>- Begin drafting chapter 4 – how students are affected by inquiry lessons</td>
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<tr>
<td>Mar. 22</td>
<td>- Submit thesis format review</td>
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<td></td>
<td>- Complete Chapter 4</td>
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<td></td>
<td>- Begin Chapter 5 – teacher thoughts about inquiry</td>
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<tr>
<td>Mar. 29</td>
<td>- Complete Chapter 5</td>
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<td></td>
<td>- Complete conclusion</td>
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<tr>
<td>Apr. 5</td>
<td>- Complete thesis draft</td>
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<td>Apr. 12</td>
<td>- Submit Thesis!!</td>
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<td>Apr. 19</td>
<td>- Revise inquiry draft as needed</td>
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<tr>
<td>Apr. 26</td>
<td>- Submit Inquiry</td>
</tr>
<tr>
<td>May 3</td>
<td>- Prep for conference</td>
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<td>May 10</td>
<td></td>
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</table>

Schreyer format review due
Inquiry paper draft due 4/16
Schreyer Thesis due
Final inquiry paper to webmaster by 5/16
ANNOTATED BIBLIOGRAPHY:


This is a website that was created for a workshop. The workshop focused on helping teachers learn to use inquiry in their classrooms. It includes videos and worksheets that were used at the conference. This website is helpful to me because, although I did not attend the workshop, the materials are still very informative. The videos give me more ideas for how inquiry can be incorporated, and there is also some organizational materials on this website to help inquiry lessons run smoother.


This paper provides an overview of what student engagement really is, and some ways that teachers can look at student engagement. It talks about student self-report measures, checklists, observations, work samples, and case studies.

The information in this paper directly correlates to my inquiry question as it examines ways to engage students beyond “traditional” teaching methods, such as the use of inquiry. I am most interested in how much inquiry science engages students, and this gives me some invaluable ideas for designing my data-collection methods.


This book is written to help teachers see how inquiry science lessons can spark student ideas. It focuses on inquiry that is driven purely by student ideas. The book also contains reflections by the authors on their own use of inquiry lessons in their classrooms, and very detailed case studies of lessons in action.

The aspect of the book that attracted me is that the authors provide so many ideas to help inquiry run smoothly. They talk about ways to start inquiry processes with students, and for helping to guide students within a classroom setting without discouraging their excitement.


This article discusses a teacher-preparation program at Eastern Michigan University. It begins by claiming that American citizens are practically scientifically illiterate, and that the blame for this is placed on the elementary teachers’ shoulders. The authors go on to say that it is not the teachers’ faults, but that the solution is better teacher-prep courses. It discusses their new program in which teachers are educated in not only the science topics more thoroughly, but also in the process of student investigation.

I have long contended that in order to have an effective society where new solutions and inventions are developed regularly, we need to have a scientifically-competent society. And in order to do that, the process must begin in elementary school. This article supports my idea, and goes on to say that by helping students experience science in a more meaningful way (such as inquiry), we as teachers will be setting them off on the right foot.

This resource is the national standards for science education. It contains an overview and introduction as well as important terms to help the reader understand the book better. This is followed by the standards for science teaching, for professional development of science teachers, for science education assessments, for content standards, and for science education program and system standards.  

This is useful because as teachers, we are consistently held to national, state, and regional standards. It is especially important to know what is included in national standards because most states and districts base their own standards off of the national ones. Knowing how my science inquiry lessons fit with the national goals for science lessons helps guide me to help my students do well on the traditional tests that they are required to complete.


This book is a companion to the National Science Education Standards. It has sections talking about how inquiry appears in the national standards, it has many examples of real classrooms using inquiry lessons, and it has answers to questions that many teachers have about inquiry.  

Inquiry is very useful to my inquiry project in many ways. As I designed my glacier lessons, it helped me think about how to place inquiry elements into the lessons. It talks about different levels of inquiry that can be done in a classroom. And the views we get of real classrooms using inquiry are invaluable. They give me another glimpse, outside of my own classroom, of how students relate to inquiry lessons.


While this report is challenging to wade through, it contains some very valuable information. It outlines results of math and science tests in the United States, and compares those to test scores of other countries. It also talks about trends in math and science education and touches on some good practices within those.  

This information is useful because, due to the gap in scores between us and other countries, it shows that there is definitely room for improvement in our science classes. Having this proof helps me demonstrate why it is important to look hard at the way we teach science.


In this book, the authors claim that students become better scientists and enjoy science more when authentic science inquiry is combined with authentic science writing. It provides detailed advice for beginning this process in your own classroom, including how to set up the classroom, and how to measure your progress once a science unit is begun.  

This book has some great ideas for how I can engage students and stimulate their curiosity. It even begins chapter one with fifth graders talking about how enjoyable their science classes are. There is a lot of evidence in this book showing why these techniques work.

This article takes a look at why it's important for students to be curious, and it shows some ways that inquiry science lessons help with this. This helps my paper because it supports my hypothesis, that inquiry lessons fuel student curiosity. It also gives me some ideas of things that I can look at to see whether student curiosity is growing or not.


This book discusses a variety of science topics and provides basic understanding for teachers. It is not designed to be comprehensive, nor to cover all information an elementary teacher would need when teaching that topic. Instead, it is a great place for teachers to start their research on a topic, and to guide them to narrow their focus. It also is incredibly helpful in providing some information about what students might be thinking about these topics.

For my project, it is most useful because of that last part. Knowing what misconceptions students may have about science helps me assess what I need to tell them. This not only applies to individual processes, but to scientific thought as a whole. In order to guide students to curiosity and excitement, I need to find out what it is they perceive as being bad and good about science, so I can steer them away from the one and towards the other. This will help me develop teaching kits that contain lessons that will be most valuable for the students.
References


VITA

Janet C. Alley

Education: THE PENNSYLVANIA STATE UNIVERSITY
The Schreyer Honors College
B.S. in Elementary and Kindergarten Education (K-6) Expected May 2010 (with honors)

Certifications:

National Association for Interpretation-Certified Interpretive Guide Attained Summer 2008-present

Fédération Internationale de Football Association (FIFA)-Grade 8 Soccer Referee
Attained November 1998-present

Professional Experience:

Professional Development School Intern: Chosen as one of 58 Penn State University Elementary Education majors to participate in a collaborative 185 day, full-time elementary student teaching internship in a fifth grade setting in the State College Area School District (PA). This program received the 2009 National Association of Professional Development (NAPDS) Award for Exemplary Professional Development School Achievement as the latest in a series of national awards.

PDS Fifth Grade Intern August 2009-June 2010 State College, PA
Gray’s Woods Elementary School

Professional Development School Intern: Chosen as one of 58 Penn State University Elementary Education majors to participate in a collaborative 185 day, full-time elementary student teaching internship in a fifth grade setting in the State College Area School District (PA). This program received the 2009 National Association of Professional Development (NAPDS) Award for Exemplary Professional Development School Achievement as the latest in a series of national awards.

Interpretive Park Ranger Summer 2009 Mount St. Helens NVM, WA

Assistant to the Director Fall 2007-Present State College, PA
Friendship Tutoring Program

Related Experience:

Summer Intern Summer 2008 State College, PA
Millbrook Marsh Nature Center

Camp Counselor Spring 2008 Petersburg, PA
Shaver’s Creek Environmental Center’s Outdoor School

Kindergarten Tutor Fall 2006-Spring 2007 State College, PA

Camp Counselor 2000-2007 Petersburg, PA
Shaver’s Creek Environmental Center

Honors and Activities:

- In progress of completing Schreyer Honors College Thesis
  - Will be presented at the Schreyer Honors College Campaign Kick-off Showcase
  - Will be presented at the Professional Development School Inquiry Conference
- Dean’s List Standing: The Pennsylvania State University, achieved 7 semesters (expected 8)
- Pi Lambda Theta: International Honor Society and Professional Association in Education
- Phi Kappa Phi: Collegiate Honor Society
- Kappa Phi Service Organization: Secretary, Editor/Historian
- Student Pennsylvania State Education Association