USING GUIDED INQUIRY TO IMPROVE PROCESS SKILLS AND CONTENT KNOWLEDGE IN PRIMARY SCIENCE

by

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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July 2012

DEDICATION

This project is dedicated to the memory of my mother, Susan Kay my very first and best teacher.

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ABSTRACT

This action research project was developed to describe and identify how student process skill development can increase the content knowledge of second grade students in the science content area of living and non-living things. Students participated in a ten-week study that used the inquiry model of instruction to teach science content relating to plants and animal features, lifecycles and characteristics of living things. The findings showed an increase in content knowledge of students and development of process skills of observation, questioning and communicating.

INTRODUCTION AND BACKGROUND

Teaching and Classroom Environment

I currently teach second grade at the Hardin Primary School in Hardin Montana. Our school educates kindergarten through second grade. We have 328 students. The school population is made of 86% Hispanic and American Indian students. My class consists of 20 students including 8 girls and 12 boys. My class contains 17 American Indian students and 3 Caucasian students. Currently 16 students live with both parents, 2 live with grandparents, and 2 live in single parent homes. Half of the students live in Hardin and six live in Crow Agency on the Crow Reservation; four students live in the surrounding communities of Lodge Grass, St. Xavier, Lame Deer and Busby (Power School, 2011). This class has 11 students at grade level or benchmark, and 9 below grade level in reading as measured by DIBELS monitoring system (AIMSweb, 2011). In math this class began the year with 5 students at grade level or benchmark, and 15 students below grade level as assessed by criterion referenced default scores monitored by (AIMSweb, 2011).

Focus Statement

The purpose of this study is to determine the effects, if any, on the students' science content understanding through the development of the process skills of observation, questioning and communicating using the guided inquiry framework of learning.

The Montana Science Content Framework curriculum for the State of Montana has been adopted by Hardin 17H & 1 School District. This requires the instruction of each standard to be taught so as a result "students, through the inquiry process, demonstrate the ability to design, conduct, evaluate and communicate results and reasonable conclusions of scientific investigations" (OPI 2009). As I planned my study, I aligned the process skills of the science content standards for my grade level. The relationship between the process skills and the science content standards are presented in Table1.

Table 1
Process Standards and State Content Standards

Science Process Skills	**Montana Science Content Standards** **Standards 1 and 3**
Observation Questioning Hypothesizing Predicting	Content Standard 1 Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.
Planning and Investigating Interpreting Communicating	Content Standard 3 Students, through the inquiry process, demonstrate knowledge of characteristics, structures and functions of living things, the process and diversity of life, and how living organisms interact with each other and their environment.

This study included the use of the science inquiry framework developed by Wynne Harlan as presented at the Exploratorium Institute For Inquiry in San Francisco, CA (2011). This approach to inquiry includes designing the inquiry activities to meet the goal of the learning experience. Students began this ongoing process by first exploring materials, making observations, and raising questions related to the content goal. Then, using the developed questions students worked in small groups to carry out investigations about the topic of inquiry (e.g. living things). Students interacted with materials, making observations, proposing tentative explanations, making and testing predictions and, by revisiting questions, using new observations. They recorded and represented their observations in written form by writing and drawing. Finally, the students shared their understandings by looking at the results of the investigations and by sharing the learning of the scientific concepts (Institute For Inquiry, Fundamentals of Inquiry, A Professional Development Design Workshop, 2011).

These lessons required on going reflection and formative assessment of students learning by the students and the teacher in order to increase their understanding of science content and improve their ability to use the process skills of observation, questioning and communication.

Research Questions

1. In what ways did teaching and development of the process skills of observation, questioning and communication affect students' attitudes and their self-confidence in learning science?

2. What did students say was the most helpful things for teachers to do to improve students' learning about using observation, questioning and communicating?

3. In what ways did teaching and development of the process skills of observation, questioning and communication affect the students' learning of science content?

CONCEPTUAL FRAMEWORK

Introduction

The teaching of science in a K- 12 classroom has many influences and considerations. Teaching "science as practice" is described in *Taking Science to School: Learning and Teaching Science in Grades K-8,* (National Research Council, 2007). This book states that most students have experiences to develop and sustain knowledge and understanding of the natural world, by generating and evaluating scientific evidence, and explaining and understanding how scientific knowledge is constructed and to participate in science as practice and discourse (NRC, 2007 p. 251). The current state of science education in the K-12 classroom consists of using current research and practice, national and state adopted content standards and an upcoming new national framework for science education to better prepare students for the 21st century.

Most recently, the National Resource Council (NRC) has published *A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (NRC, 2012). This framework was developed by a committee from the National Academy of Engineering, the Institute of Medicine, and the National Research Council that together form the National Academies of Sciences. This framework has been designed to act as a new framework for science education standards. The framework consists of four "core areas" including: a) the life sciences, b) physical sciences, c) earth and space sciences, and d) engineering, technology and the applications of the sciences. The framework includes seven "crosscutting" concepts that apply to many fields of study. Teachers are encouraged to use the same language to present concepts. The science and engineering practices are included in eight of the "key practices" that will require students to learn how to ask questions, define problems, analyze and interpret data, and construct explanations and to design solutions to problems (NRC, 2012).

In addition, the Partnership for the 21st Century Skills (P21) has also developed a new framework for 21st century learning. This framework has been adopted by some states and is considered the new framework for content standards in education. The 21st century outcomes include core subjects called the three "R's" and 21st century themes of global awareness, financial, economic, business and entrepreneurial literacy, civic, health, and environmental literacy. The "4 C's" are learning and innovation of skills in critical thinking and problem solving, communication, collaboration, creativity and innovation. In addition this framework encourages information, media and technology skills as well as life and career skills. The P21 organization believes this framework will prepare students for a global technological society (P21, 2011). Both frameworks support the teaching of science content and skills in conjunction with each other.

The National Science Teachers Association (NSTA) has recommended that the science education community support "21st century skills" as is aligned with previous publications of the NSTA about quality science education which includes "quality inquiry-based curricula and support materials promote science learning and 21st century skills" (NSTA, 2004, p. 2).

The National Science Education Standards (NSES) regarding the content and policies of science instruction in grades K-12 were designed and published by the National Committee on Science Education Standards and Assessment along with the National Research Council in1996. The NSES were not a national curriculum but rather a set of criteria for schools to follow in areas such as science teaching, professional development, assessment, content, science education programs, and science education systems.

The *Inquiry and the National Science Education Standards: A Guide for teaching and Learning* was published by the Center for Science, Mathematics, and Engineering (CSMEE) in 2000. This guide was an addendum to the NSES standards. This publication provided school districts a resource for using inquiry within science instruction at all grade levels. Science inquiry is defined as “abilities of a student to be able to design and conduct scientific investigations, and to the understandings they should gain about the nature of science inquiry” (CSMEE, 2000, p.xv). Inquiry science instruction requires students to use thinking skills and processes real scientists use to learn about the natural world. Although process skills fall under the umbrella of inquiry, they are specific skills used in the science inquiry process. The American Association for the Advancement of Science Benchmarks (1993), detailed in *The Nature of Science* the development of a scientific worldview, scientific inquiry, and scientific enterprise within the science content along with a specific guide for each grade level. The National Science Teachers Association (NSTA, 2004) recommended the use of scientific inquiry as a teaching approach and stated that teachers must support students participating in and developing an understanding of science inquiry and strive to incorporate inquiry with the content knowledge. Therefore the process skills were embedded with inquiry and content learning and are developed throughout the process. These standards call for the use of an inquiry process model for teaching, formative assessment, and professional development for teachers and emphasize that this model should be based on research and best practices.

According to the Exploratorium, the science process skills are defined as tools that students use to investigate the world around them (Exploratorium, 2011). The process skills include observing, questioning, hypotheses, predicting, planning, and investigating, interpreting and communicating. Process skills are explained and described as raising questions, developing hypotheses, predicting, using observation, planning and conducting investigations; interpreting evidence and drawing conclusions; communicating, reporting and reflecting; curiosity and respect for evidence, and flexibility (Harlen, 2006). Many of the process skills overlap and depend upon each other. Observing is considered using the senses to gather information about an object, event, or phenomenon. This includes noticing differences and similarities, classifying, measuring and identifying observations. Questioning is the raising of questions about the object event or phenomenon that can be tested or researched. Communicating is representing observations, ideas, theoretical models, or conclusions by talking, writing, drawing, and making physical models (Exploratorium, 2011).

The Office of Public Instruction in Montana has adopted the Montana Science Content Standards Framework (2009). This framework contains one inquiry standard and five content standards, rationales, benchmarks and performance descriptors. The Montana standards are based on the NSES, standards (NRC, 1996) and are written with the inquiry process as the manner in which students may learn content knowledge. The definition of inquiry in the Montana Science Content Standards Framework is quoted from the NRC,

> a search for knowledge, a systematic process of teaching and learning where the learner engages in scientifically orientated questions, gives priority to

> evidence in responding to questions, formulates explanations from evidence, connects explanations to scientific knowledge and communicates and justifies explanations. (NRC, 1996, p. 25-26)

Montana has adopted the NRC Inquiry Continuum (Appendix A), for use in the instruction of inquiry within the five other strands of science instruction for K-12 (OPI, 2000). This continuum indicates that the more learner self-direction the less teacher-centered instruction, or support materials, needed in the investigation. The inquiry design relies upon the content and goal of the investigation as well as the skills of the students (Exploratorium, 2011). Effective inquiry instruction requires scaffolding, and this can involve the teacher choosing either directed, guided or full inquiry. Scaffolding is the amount of teacher support given to the learner. During a directed inquiry lesson the teacher or the materials direct the instruction. This may also provide structure for students learning the inquiry process. The guided inquiry places the teacher in the role of a facilitator who allows the students to continue to develop inquiry skills and independence in the practice. This inquiry approach is most useful to illustrate a science concept, support science literacy and build student confidence in the inquiry process. The open inquiry design gives students the freedom to apply knowledge and to design investigations, articulate and answer questions, evaluate explanations based on evidence, communicate and justify their explanations using comparison and evaluation of alternatives based on experience and conclusions (Ostland, 2009).

The State of Montana Science Standards is well aligned with the new *K-12 Science Education Framework* (NRC, 2012). The new framework is focusing on including key practices such as scientific and engineering practices that are embedded in instruction including having students ask questions, define problems, analyze and interpret data, and constructing explanations and designing solutions to given problems (NRC, 2012). The inquiry model will provide a pathway to achieving the goals of the framework.

Science instruction includes experiences for students to "lively engage in the practices of science; conducting investigations, sharing ideas, specialized ways of talking and writing, mechanical math, computer based modeling, development of representation of phenomenon" (NRC, 2007 p. 251).

Science instruction requires teachers to provide guidance and support for students to engage in "social interactions" during science investigations, using the "appropriate language of science", and use of "scientific practices" and materials and clear direction as they develop the skills for science learning (NRC, 2007 p. 265).

In order to provide inquiry instruction and the development of process skills or the "practice of science" teachers will require professional development, and formative assessment practices in order to better design instruction. Formative assessment is a tool to directing the instruction of science. Formative Assessment is critical to allow teachers to plan support and assess the quality of student experiences when learning science as practice (NRC, 2007 p. 280). Assessment must be an ongoing process that focuses on the learning of the student as well as the goals of instruction. A formative assessment cycle begins as the teacher *collects* evidence of student learning and *interprets* the thinking of the students and *determines* the next steps for students (Exploratorium, 2011). As the students' progress the cycle is repeated and skills, content knowledge or attitudes are developed and defined.

Although research may support the use of inquiry model for instruction in science, the implications for other content areas are intriguing. I was not able to locate and read research relating to the use of inquiry within other content areas. In *A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (NRC, 2012) an implication is made for a connection between crosscutting concepts and "key practices" that require students' use of problem solving skills across many content areas.

In conclusion science education requires the understanding of current practices, framework design, curriculum and instruction related to the inquiry model and formative assessment. This study will reflect the requirements of effective instruction in science, the current national standards and upcoming new framework for content and skill development for students' learning science and using of process skills within the model of inquiry.

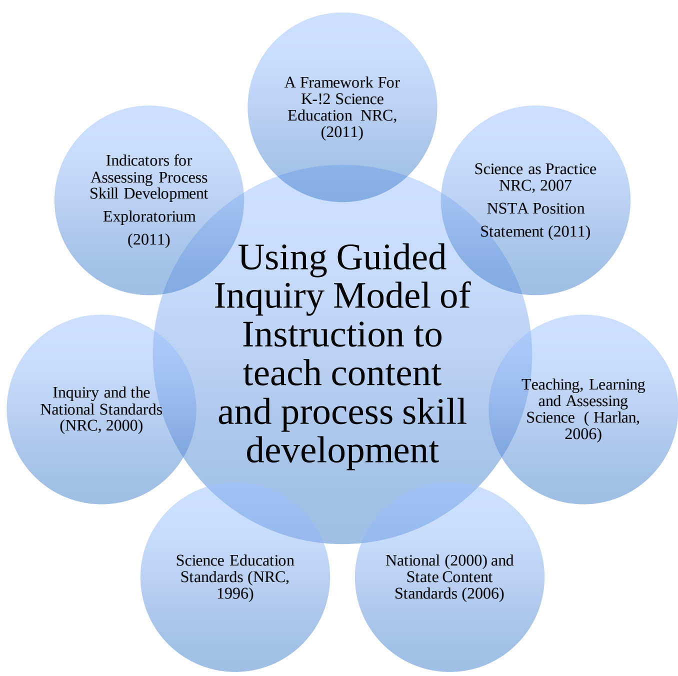

Figure 1. Model for capstone research project.

METHODOLOGY

Introduction

The goal of this section is to provide a detailed description of the research design used to test the using of inquiry to teach science content and students' development of the process skills in students. I designed a ten-week study using the content objectives for the learning outcomes for science and the inquiry model. I also included a formative assessment tool, an attitude toward science survey, a science probe, a student observation rubric, and informal interview protocols. Students were given a pre and post Science Unit Test for the unit of study.

Setting and Student Population

This study took place in my 2nd grade classroom of 20 students at the Hardin Primary School in Hardin, MT. I had twelve boys and eight girls. The students' ethnicity included 17 American Indian (Crow and Northern Cheyenne) and three non-Indian students. Ten students lived in Hardin, and 10 students lived on the Crow and Northern Cheyenne Reservations.

Treatment

The lessons were given three times a week. All students were encouraged to participate in the lessons. Students worked with a partner, in groups, and individually to accomplish tasks. They were asked to explain their thinking in oral and written form. The Montana K-12 Science Content Standards (OPI, 2009) have been adopted by the Hardin 17H & 1 School District these standards are based on the National Science Education Standards (NRC, 1996). These science standards are written so as to include the learning framework of inquiry. In an effort to provide inquiry learning I devised a plan for the teaching of the science content about living things, characteristics of plants and animals, life cycles, functions of plant parts, and animal classification using the inquiry framework and process skill development.

The framework for inquiry that I used is based upon the work of Wynne Harlan (2000). The Institute of Inquiry at the Exploratorium in San Francisco, CA has developed an approach that I will be using to design instruction. The lessons were developed and ongoing beginning with the inquiry starter which was the exploring of materials, making observations and raising focus questions. Then the students worked in pairs, independently or in small groups and used the focus questions to carry out investigations with given materials. During the focused investigations students interacted with materials, made observations, made predictions and tested them, revisited questions with new observations, recorded and represented their thinking with writing and drawing. The sharing of the understandings gave students a time to explain their thinking and communicate and learn from each other (Institute for Inquiry, 2011). The timeline of the treatment is included below.

Table 2
Implementation Timeline

Projected TimeLine	**Inquiry Framework Focus**	**Science Content**	**2nd Grade Inquiry Goals**	**Data Collection Tools**
Dec. 2nd	Introduce Inquiry Framework	Unit Pretest Unit Test (20 items)	Safety Rules Which Tool do I use? (Gathering Data)	Attitude Surveys
Dec. 9th	Observation Inquiry Starter: Living Things Probe	Living Things Characteristics of living things	Explain orally or in writing observations of investigation	Probe/Living Things Interviews
Dec. 16th	Questioning Student develop questions based on probe	Plants/Animals Compare lifecycles of plants and animals	Formulate orally or in writing appropriate questions	Observation Rubric
Jan. 6th	Hypothesizing Prediction Focused Investigation: Given materials students design investigation	Stages of life cycles of plants and animals, parts and adaptations	Formulate predictions based on prior or new knowledge and on investigations	Observation Rubric
Jan. 13th	Investigate Interpret Sharing Understandings: Students share about content learning	Life Cycles of plants and animals	Describe orally and in writing a valid test in an investigation (can be repeated)	Observation Rubric
Jan. 20th	Inquiry Starter Pose questions about living things	Characteristics of living things Animal groups	Formulate orally or in writing appropriate questions	Observation Rubric
Jan. 27th	Focused Investigation: Given materials design and investigate	Living Things Animal groupings	Formulate predictions based on prior or new knowledge based on investigations	Observation Rubric
Feb. 3rd Feb. 10th	Interpret Sharing Understandings: Students share content learning	Living things change and grow How can we show what we have learned?	Describe orally and in writing a valid test in an investigation (can be repeated)	Observation Rubric
Feb. 17th	Sharing Understandings Make a Model	Living Things		Is It Living Probe Interviews
Feb. 24-Feb. 27th.	Make a Model share ideas with classmates Final Test	Unit 2 Test (20 items)		End Survey Interviews

This study included ongoing reflection about my students by me using an observational rubric that I created based on the "indicators for assessing process skills development." The behaviors in the observational rubric have been adapted from *Teaching, Learning and Assessing Science 5-12* by Wynne Harlan (2000, pp. 147-152) (see Appendix B).

The science process skills can defined as "basic" or "integrated". The basic skills include observing, inferring, measuring, communicating, classifying and predicting. The integrated skills include controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Padilla, 1990). Scientific thinking is an integral part of the learning process for students. In order to develop the science process skills students must be given time to practice and use such skills. In order to support students' growth and learning I will give non-judgmental feedback and focus on what the student needs to do next in their thinking or investigating. I will need to avoid giving praise by wording my feedback in a manner that poses a question about how the student was thinking. For example, "How did you decide which is the best________?" Can you show me that in another way?" Harlan (2001, p. 130). I will include formative assessments, interviews, observations and ongoing reflection to measure the growth and change for my teaching and my students learning during this project.

Methods of Data Collection and Data Analysis

The methods of data collection and analysis were used to monitor students' science attitudes toward science learning as they were introduced to inquiry and specific process skills, as described under Treatment. I designed this study to examine the best teaching practice for teaching the science standards through the inquiry model of instruction and the development of student process skills. As described in the Conceptual Framework for this paper and the Treatment section above, this model has been developed based on Wynne Harlens' research (2000) regarding effective science instruction. As explained earlier, the inquiry process requires students to learn science content by using process skills of observation and exploring, questioning, communicating, hypothesizing to test ideas and interpreting evidence (Exploratorium, Institute of Inquiry, 2011).

The data triangulation matrix illustrates the data sources and focus questions to be examined during this study.

Table 3
Data Triangulation Matrix

Research Questions	Data Source #1	Data Source #2	Data Source #3
In what ways does the teaching and development of observation questioning and communicating affect students' attitudes in science?	Pre-Attitude Survey and interviews	Case Study	Post-Survey and Interviews
What do students say will be the most helpful things for teachers to do to improve their learning of observation/ questioning and communicating?	Interviews	Interviews	Interviews
In what ways does teaching and development of process skills of observation/ questioning and communicating affect the students' learning in science content?	Pre-Science Unit 2 Test Pre-Observational Rubric	Formative Assessments Probe	Post-Science Unit 2 Test End-Observational Rubric

Student Science Attitude and Self-Confidence Survey and Interview

I chose the self-confidence survey for my initial data collection (Appendix C). The purpose of the self-confidence survey is to measure students' attitudes and confidence in learning new skills and material (Angelo & Cross, 1993). The goal of my study was to measure the students' confidence in their ability to use process skills of observing, questioning, and communicating as well as to determine which factors may affect their learning and how to continually provide meaningful changes in my instruction to meet the students' needs. The survey was given at two different times, at the beginning of the research project and at the close of the project. I also interviewed six students at each point so that these students' survey and interview results could be used together in case studies. I designed this survey by aligning the process skills of observation, and questioning within the statements shown in Table 4 below in order to measure the effectiveness of the inquiry model that I was using. In addition, the survey was piloted with a small sample of students in another second grade classroom to ensure that it was readable and clear to this audience. Survey and interview data allowed me to assess how effective my instructional strategies are and why they are effective (Hendricks, 2009).

Table 4

Process Skill Alignment with Survey and Interview Question

Process Skill	Survey Question	Interview Question
Observation (using senses to gather information)	1. I am good at observing things we study in science. 2. I am good at noticing similarities and differences.	What are some things your teacher could do to help you learn as much as possible about using observation? What could you do to help learn how to observe? When do you use observations during the school day?
Questioning (posing questions based on observations)	7. I am good at thinking of questions that can be tested in science. I am good at thinking of questions that may be testable when we do science.	What are some things your teacher could do to help you learn about Questioning? What can you do to learn how to ask better questions? When is it important to ask a question?
Communicating (writing, drawing and telling about science activities)	5. I am good at explaining my thinking. 6. I am good at writing or drawing about my thinking.	What are some things your teacher could do to help you learn about Communicating? What can you do to help yourself to communicate your thinking? Is there another time during the school day when you might have to explain your thinking?

The interviews were conducted informally and required an audio recording in order to have accurate information. Questioning and interviewing students can be an ongoing process that provided insight into instructional practices and when used with observation methods the two forms of data can work together “to gather complementary data” (Mills, 2011, p. 78).

Student Survey: Methods of Data Analysis

I designed the Student Science Attitude and Confidence Survey, as well as the student interviews, by matching the statements with the specific goals of my project. I also included the language of inquiry. The survey items are considered to be closed-ended. Each item was tallied and the class tallies were counted for each item, and across items representing each process skill, was recorded for later comparison. Also each survey was scored for each individual student. This allowed for quantitative analysis of data. I then monitored the changes in the students’ answers and responses of the class as a whole, as the treatment progressed (Hendricks, 2009). My data displays included charts to show themes or patterns in the data. It is important to record and begin to analyze data immediately to avoid confusion about what actually happened or was said, to fill in gaps in the data, and to identify themes during the action research process. Analyzing the data included using phrases from the Likert scale that is part of the survey, and assigning a numerical value to each response such as follows: mostly =3, sometimes = 2, and not often = 1. This allowed me to show the range of responses, percentage of the responses and the most common responses (Hall 2009).

Student Interviews: Methods of Data Analysis

For the analysis of the open-ended questions from the student interviews I used a process called thematic analysis. Thematic analysis is a process to look for themes in qualitative data (Hendricks, 2009). The interview data was recorded using an audio recorder and then transcribed to textual form. Once the data was in textual form I was able to determine patterns by coding for purposes of understanding and interpreting data. For example, if a student described or explained how they were thinking I would code this as perspective data because it is giving insight into the students' perspectives. I then and assigned a sub-code regarding the topic. The resulting themes and patterns created a clearer picture of the students' experiences.

"Is It Living?" Formative Assessment Probe

Following the survey students were asked to complete the "Is It Living?" probe (Keely, Eberle, & Farrin, 2005) and a subsequent interview for clarification. The probes' design allowed the teacher to gather knowledge about how their students are thinking about living things (Appendix D).

In 1998, Black and William published, "*Inside the black box: raising standards through classroom assessment.*" This study details the value of formative assessment as a means for driving instruction and the raising of standards of achievement. Formative assessment can be described as "assessment for learning." "The framework for formative assessment consists of collecting evidence in a planned and systematic way, interpreting the evidence to produce a judgment, and communicating using the judgment," (Harlen, 2009). Teachers can use formative assessment tools to design instruction and improve student achievement. The formative assessment tool I used is called a formative assessment probe. The design of this probe was based on content and principles in the *National Science Education Standards* (NRC, 1996) and *Benchmarks to Science Literacy* (AAAS, 1993). The researchers piloted these probes with many students with diverse backgrounds and across several grade levels. The researchers were able to reveal the common misconceptions among students for the science benchmarks and standards. The goal of the probe is to reveal misconceptions based on students' experiences. This probe provided insight into the students' understanding of science content and their development of the process skills of observation, questioning, and communication, the focus of Research Question 2 in this study. Therefore, the data collection tool I chose to begin the unit of study is called the "Is It Living" Probe (Appendix D). I based this probe on a similar one I discovered in *Uncovering Student Ideas in Science* by Keely, Eberle and Farrin (2006). This book also discusses the development of students' thinking at a variety of stages. This probe was developed to "elicit student ideas" (p. 124) about what they understand about living and nonliving things. Once I was able to analyze their thinking I was able to uncover misconceptions, gaps in their past instruction and gathered a sense of how they were conceptualizing the characterizations of living and non-living things. I was able to adjust my instruction to better meet the needs of my students as well as providing a tool for students to use for inquiry.

I planned to give the probe at the beginning of the science instruction in order to identify the students' ideas about living and nonliving things. My research plan was to determine if the use of process skills can improve the learning of science content. The students need to be given opportunities to take risks and talk about their thinking. The class needs to develop a community of cooperation and trust. The probes developed in *Uncovering Student Ideas in Science* by Keely, Eberle and Farrin (2006) have been researched and refined in order to be effective for science teaching. Following the probe I shared the information with my class and modeled for students the process of developing questions that may be used to investigate in our unit of study of plants and animals. The probe was given again at the close of the unit in order to check understanding. Students may not change their ideas about living things but they will be given the opportunity to learn truths about content using inquiry.

Triangulation can be accomplished by using student-generated artifacts, observations and ongoing interviews.

I used the formative assessment probe in order to begin the inquiry process with my class. The probe started our unit of study by posing a question and set the stage for students to use the process skills of observation, questioning and communicating. Following the probe and short interview to clarify the student thinking each response was tallied and recorded as a correct or an incorrect response. Then I totaled the number of responses and found a percentage of students' correct responses. I was able to find outliers and trends in the students' responses. For example, many young children may mark "the wind" as living because it moves. The underlying misconception is that living things need only one characteristic to be considered alive. I planned to discuss the results of the probe with my class and began our study of living things while also constructing new ideas about living and non-living things.

<u>Observational Process Skill Rubric</u>

I designed a rubric to illustrate student behaviors as they develop during the science lessons (Appendix B). Students were asked to participate in investigations to learn about the living world of plants and animals. As the students practiced and used the skills of observing, questioning, planning interpreting, hypothesizing, predicting, and communicating they required support and direction from the teacher. This rubric was based on the "list of abilities" necessary to do science inquiry from the National Science Education Standards. The descriptors are taken from Wynne Harlens' *Teaching,* *Learning, and Assessing Science, 5-12* (Institute for Inquiry, 2011). This rubric allowed me to observe the students and focus on their observing, questioning and communicating skills. Then I was able to support their learning in a more individualized manner. I also was able to determine which skills may need more instruction and guidance. I planned to observe four students for each science lesson. I planned to give them a point for each behavior I observe with a possible total of ten points. I was going to track student scores and look for improvements and change. Students were observed weekly. I asked another teacher to observe the same students using the rubric to check for bias.

My action research study consists of data collection using formative assessments such as the assessment probe and the process skill rubric. I felt this was a start for a triangulation approach needed to provide valid and reliable data that will support the goal of my study. The goal of my study was to measure the students' ability to use process skills of observation, questioning and communicating as well as to determine which factors may affect their learning of science and math content within the inquiry model of instruction.

<u>Science Content Unit Tests</u>

I also administered pre and post science unit tests to measure growth in content knowledge (Appendix E). The unit test was designed to match the essential learning expectations and benchmark goals for the Montana Science Content Standard 3, "students through the inquiry process, demonstrate knowledge of characteristics, structures and functions of living things, the process and diversity of life, and how organisms interact with each other and their environment" (OPI, 2009 p.11). This test had a twenty-point value that included matching, fill-in-the–blank and short answers. It was designed using the 2nd grade Houghton Mifflin Science book published in 2007. Students received an overall score for both post and pre-test. The test items are indicated below and aligned with the content standard it addresses.

Table 5
Test Items Houghton Mifflin 2007 (Teacher Created)

#1-4	#5-6	#7	#8	#9	#10	#11
Matching Living/ Non-Living	Life Cycles Animal Groups	Responding To a How …question	Predict what caterpillar will look like… Explain thinking…	Order Life cycle of plant	Write how frog and fish different/alike	Label /Draw lifecycle of an insect
SD 2	SD 2	SD 1 Inquiry	SD 1 Inquiry	SD 2	SD 1 Inquiry	SD 2

The content test for this unit was created using Houghton Mifflin Science Assessment Resources purchased by our school district (Houghton Mifflin 2007). This set includes big books and videos and materials to teach the content. I designed the test to test the content, vocabulary and process skill abilities. The test has a matching vocabulary, identifying animal groups, short answer questions, ordering plant life cycle, and drawing and labeling life cycle of an insect. (Appendix E).

Teacher Reflective Journal

I planned to use a reflective journal each week during this action research project. As I developed and extended my ideas, thoughts and findings I used the journal as a place to focus my thinking, and grow professionally. I also used this journal to track interruptions and problems that arose during this project. The journal provided a place to consolidate my thoughts and questions throughout the project.

As students progressed through the unit of study they used all of the process skills in the inquiry model. For data gathering purposes I focused on the observation, questioning and communicating skills of my students using a rubric I designed based on "indicators of process skill development" (Appendix B).

Validity and Reliability

The validity of this study was determined by how well the gathered data measures the focus areas of the study, including student attitudes, confidence and learning and how well the data reflects the students' true experiences in the study. The validity of this project will include truth-value validity and outcome -based validity (Mills, 2011). The truth-value validity is providing a multitude of "research findings for the context that was studied" (Hendricks, 2009, p 112). Outcome-based validity requires that an "action emerging from the study leads to a successful resolution of a problem you are studying" (Mills, 2011, p. 112). This became evident, as I was able to make changes in best practices that have proven to be helpful to instruction. In order to present truthful data I needed to use a variety of data sources and to maintain a persistent and prolonged observation during my lessons. I used the observation rubric each time I engaged students in a science lesson.

Reliability is consistency in measurement. In order to maintain reliability I needed to reflect upon the results of my data collection and question the consistency of the data collected. Would it be the same if given again? I planned to include a mini retest giving the survey to a few students and comparing the data to the first survey.

Table 5 below provides a detailed data collection timeline stretching from mid-autumn to early spring of the year the study took place.

Table 6
Timeline of Data Collection

Date	Self-Confidence Survey/Interviews	Peer Debriefing of Survey	Class Member Check of Survey	Self-Reflection Journal	Observational Rubric
Nov. 4th	X Pre-Survey Science	X	X	X	
Nov. 7th	*Mini-retest			X	
Nov. 11th		Is It Living Probe/ interviews		X	
Nov. 18th				X	X
Nov. 30th				X	X
Dec. 2nd		X	X	X	X
Dec. 16th				X	X
Jan. 6th				X	X
Jan. 20th		X	X	X	X
Jan. 27		X	X	X	X
Feb. 5th		X	X	X	X
Feb. 12th	Survey/ Interviews	X	X	X	X

I also included AIMS math and DIBELS reading scores of my students in order to provide additional information about my class in the background information section of my action research project. In summary, the combination of all forms of gathered data allowed me to adequately address the research questions of my study.

DATA AND ANALYSIS

Introduction

The following section will detail and outline the findings during the action research project that include Assessment probes, Student Confidence and Attitude Survey, student interviews, and a pre and post content test. Also included is a case study of a small group of students, teacher and student reflections taken at the beginning, and end of the treatment including the use of an observational process skill rubric.

Results of Data Analysis

Assessment Probe

The first assessment tool I used was the Assessment probe *Is It Living?* This probe began our study and discussion of the topic of living and non-living things. The pre-treatment probe showed students needed a better understanding of the characteristics of living things in order to be able to distinguish between living and non-living things. The post treatment probe also shows some interesting data about how students think about living things after treatment.

Following the administration of the probe I conducted a short interview to check for understanding. The probe's design allowed me to gather knowledge about how the students were thinking about living things. (Appendix D) I looked for misconceptions, and general ideas the students have about living things. I selected six students for the interviews and case study. All 20 of my students completed the survey as requested.

I introduced the idea of the probe to my class by explaining that we were going to be studying living things and learning how scientists think and work in science. I told students to mark the items that they believe are living or once were living. I went through the list with them and read each item aloud. I told them to write the reason or rule they used to decide which things were living. I offered help to students with spelling words, and explaining items if they weren't familiar with them.

The results of the initial probe showed that for the response options tree, rabbit, bear, boy, and butterfly, showed 95% to 100% of the students marked these items as living. The next items marked as living were the sun at 70%, cloud at 65% and river at 72%. Half of the students indicated the wind as living. Less than half of the students chose rock and fire as living. Surprisingly, barely more than half of the students considered a seed or an egg as living.

Table 7
Pre and Post Probe Data

Probe Item	Pre Yes Responses (n) N=20	Pre Yes Responses (%)	Post Yes Responses (n)N=19	Post Yes Responses (%)
tree	19/20	95%	17/19	89%
rock	6/20	30%	1/19	5%
fire	9/20	45%	2/19	10%
wind	10/20	50%	2/19	10%
rabbit	20/20	100%	17/19	89%
cloud	13/20	65%	1/19	5%
grass	12/20	60%	13/19	68%
seed	11/20	55%	16/19	84%
bear	20/20	100%	15/19	78%
egg	11/20	55%	12/19	63%
sun	14/20	70%	7/19	36%
boy	20/20	100%	17/19	89%
mushroom	9/20	45%	13/19	68%
potato	10/20	50%	16/19	84%
leaf	11/20	55%	7/19	36%
butterfly	20/20	100%	18/19	94%
fossil	9/20	45%	5/19	26%
river	13/20	65%	2/19	10%

The students were asked to write a statement that explained how they chose the living things. The responses are grouped by category. Five students claimed that living things are just living, giving no rule; two students wrote that God made things and that shows they are living; five students mentioned needs of living things such as water, air, food and environment. In addition, three students claimed that things are living because they move, and included the sun and wind as examples. Three students said that animals are the only living things; and three students also remarked that living things are living because they grow or change.

Interpreting and Applying Probe Data

The goal of the probe was to identify what characteristics my students understand about living things. Understanding that organisms need food, water, and shelter and that living things may grow and change was found with 25% of the students. They also indicated that they found movement and growth to be characteristics of living things. Students showed that they think that plants are not living because they can’t observe them growing, changing or moving on their own. It seemed that the students needed to understand that living things can have more than one attribute and that it may not always be observable. In order to clarify these ideas we made a list of characteristics of living things and used it as a reference as we progressed through the unit of study.

As we studied plants, animals and life cycles we began with the Inquiry Starter. This included exploring materials, making observations and raising questions as they relate to our learning goals (IFI, 2011). The initial observations were of various plants. Then students were given brine fish eggs (unknown to them) as well and were asked to develop questions about how they could determine if they are living or non-living. Students were asked to sort questions into testable and non-testable. I used the Student Process Skill Rubric to observe each group of students during the investigations. The probe was given at the end of the unit of study to show if students had changed their conceptions of living things.

Post Assessment Probe

The post probe showed that 94% of the students' responses chose the butterfly as a living thing. Also 89% of the class chose rabbit, boy and tree as living. The students' response to potato and seed was 84% of the class choosing them as living things. The response for hibernating bear was 78%. One student marked everything as living. The biggest changes begin with the responses regarding whether rock, fire and cloud are living. Responses that these were living were greatly reduced in the post-probe compared to the pre-probe. For example, 30% of the students chose rock as living in the pre-probe compared to 5% or one student in the post-probe. The responses that fire and cloud are living changed from 45 and 65% of students to 11% from pre to post probe. In the post-probe two students chose wind and fire as living. The post-probe also show a big change in the students' ideas about seed and potato. Although students did increase their responses to egg from 55% pre to 65% post- probe. These may be the result of further study or the ability to correct students' misconceptions during class discussions. The categories for written responses on the post treatment probe included eight different ideas. Students were asked to explain their thinking at the end of the probe by writing a reason or rule for their thinking. The student categories included growing, eating food, having a life cycle, breathing air, needing water, producing food, movement, shelter and having hair or hibernating. The post treatment probe showed students focused on more than one characteristic of living things such as growing, eating, lifecycles, breathing air and using water. In the pre-treatment probe, 65% of the students explained living things by the living thing being created or on the earth and therefore living, and using movement and growing as characteristics.

The implication of these probes shows that the students have made new understandings in their thinking about living and non-living things. They were able to see plants and animals as living things that progress through a life cycle.

Student Science Confidence and Attitude Survey

The attitude survey was given at the beginning of the treatment as well as at the end of the treatment. I introduced this survey to my class as a way for me to gather information about their ideas about science and how well they felt they could do different things in science. I explained that the survey was voluntary and that they did not have to give an answer if they didn't want to or if they were unsure of their answer they could leave an answer blank. I also pointed out that they could ask me if they still didn't understand the meaning of words. We discussed the categories of responses, "I feel good about (behavior) "not much", "sometimes," and "often". I interviewed six students about their understanding of observation, questioning and communicating. Data was recorded and put into textual form.

Student Survey Results

The survey results showed that 65% of the class chose "feel good often" to describe their feelings about making observations, explaining their thinking and the ability to learn science in 2nd grade. The survey showed that of 55% of the class rated "drawing and writing about thinking" (communicating) and following safety rules as making them "feel good often". Item 3, "I am good at asking questions," was rated by 50% of students as making them "feel good often" with an additional 35% choosing the “feel good sometimes” response. Item 7, “I am good a noticing similarities and differences,” had an equal distribution of “often,” “sometimes” and “not much” responses. All 20 students completed the survey. One student wrote in “ I don’t know” to item 7, “I am good at predicting why something happens during science activities,” and item 8 “ I think I will be able to learn science in 2nd Grade”. Below I compared the data from pre and post treatment to show trends in attitudes and confidence levels.

Table 8
Student Science Confidence and Attitude Pre Survey Results (N=20)

Item #	“feel good often”	“feel good sometimes”	“feeling good not much”	Total Responses	Missing Responses
1	13 (65%)	5 (25%)	2 (10%)	20	0
2	5 (25%)	12 (60%)	3 (15%)	20	0
3	11 (55%)	7 (35%)	3 (15%)	20	0
4	10 (50%)	8 (45%)	2 (10%)	20	0
5	13 (65%)	6 (30%)	1 (5%)	20	0
6	11 (55%)	6 (30%)	3 (15%)	20	0
7	5 (26%)	7 (36%)	7 (36%)	19	1
8	12 (63%)	4 (21%)	3 (15%)	19	1

Table 9
Student Science Confidence and Attitude Post Survey Results (N=19)

Item #	“feel good often”	“feel good sometimes”	“feeling good not much”	Total Responses	Missing Responses
1	11 (57%)	6 (31%)	2 (10%)	19	1
2	11 (57%)	6 (31%)	2 (10%)	19	1
3	9 (47%)	7 (36%)	3 (15%)	19	1
4	18 (94%)	1 (5%)	0	19	1
5	9 (47%)	9 (47%)	1 (5%)	19	1
6	10 (52%)	6 (31%)	3 (15%)	19	1
7	7 (36%)	5 (26%)	7 (36%)	19	1
8	14 (73%)	5 (26%)	0	19	1

Student survey scores were also analyzed individually. Each answer was given a point value on a scale of 1-3 with Often=3, Sometimes=2, and Not Much =1. The total points possible was 24, the highest possible level of self-rated confidence. In Table 9 I converted the raw scores assigned for students' self-confidence ratings into percentages.

Table 10
Individual Student Confidence Rating

Student Code Number	Self Confidence Rating Pre-Survey (%)	Self Confidence Rating Post-Survey (%)
453	79%	100%
423	95%	79%
410	100%	100%
376	100%	91%
468	83%	87%
485	70%	70%
650	75%	83%
451	70%	66%
408	50%	70%
842	54%	70%
121	66%	79%
754	58%	75%
373	75%	70%
Drop	87%	Not tested
389	87%	75%
033	83%	70%
577	87%	100%
509	91%	87%
613	87%	95%
655	100%	91%

In the pre-treatment survey the students' self-ratings resulted in a total science confidence score of 70% or higher. The students selected item 2, item 4 and item 8 which addressed confidence regarding observing, predicting, using safety rules, for ratings of “often” or “sometimes,” making these items highest ranking. Four students’ science confidence scores were 66% or lower. The lowest science confidence rating was 50% and the highest science confidence rating was students at 100%. The post-treatment results showed 47% of the students’ responses had shown an increase in the total science self-confidence score. Ten percent stayed consistent and 42% decreased their confidence score. There were three students in all with a 100% score on the post survey. The average score for the pre-treatment was 15.4 points and for the post-treatment it was 18.5 points. These point values translate to 64% and 77% respectively. Overall this shows a trend that the student self-rating in confidence was higher following treatment.

Student Survey Summary

The data in the first analysis indicates the students have a generally positive confident feeling about themselves and their science learning. The results showed that out of the eight items in the survey seven items were rated by 84% of the students as “feeling good often” and “feeling good sometimes.” This may be also do due the general positive attitude second graders have about learning and themselves.

Student Interviews

Lessons from Student Interview Pilot

I pre-tested the interview with three students from another class. These interviews allowed me to see that the students were not able to give me answers to the question about, “How could a teacher help you to learn how to improve your questioning?” I rephrased the question I tried to relate the question to the students’ experiences. I instead asked, “When are some times during the day when you might observe something? The second question was, "What can you learn to help you ask better questions?" This question did not elicit the responses I was looking for although one student said sometimes my teacher goes too fast and I have to ask for help. I changed the question to "When is a time when you might ask a question?" The third interview question was "When is a time during the day when you might have to explain your thinking?" This question was also designed to help students identify questioning and bring attention to the skill for better understanding.

Student Interview Results

I interviewed six students from my class. The student interviews were recorded and transcribed into written form. This allowed for further analyzing and planning for instruction. As I analyzed the interview I noticed that I didn't give students more than a few seconds to answer the questions. I also noticed that the students heard me say "sometimes during the day" and they thought I meant on the clock what time of day. All the students were able to say that they noticed things, but were not able to relate the observation to making a decision or how the observation can give the observer information. The students all were able to think of a question they might ask in relation to their needs. One student said he might ask if he could ride his horse and another said she might ask her parents what to eat for breakfast. The third question yielded a response that was more in relation to learning. Because the students have been using cognitively guided instruction practices during math they have had some experience in talking and drawing to explain their thinking in solving story problems. One responded that during math he counted in his head to solve a problem and he drew a picture to show his thinking. Two students talked about showing their ideas by drawing. Two students related thinking to being at home and talking with their parents. Two students gave examples of explaining her thinking during art. My interviewing techniques have room for improvement. I need to give students more time to answer. My questions need to be edited by removing “a time during the day” and extended by asking about experiences during learning time. I may have them tell an example if they are given time to think about the questions.

Post Interviews

I interviewed the same six students at the beginning and the end of the treatment period. I recorded these interviews and converted them to textual form. I was able to detect patterns in the answers. These students illuminated some of the most powerful information for the study. I redesigned my questions in order to unable the students to communicate their understandings about the process skills of observing, questioning and communicating for science. The interviews indicated some changes in the understandings about observation and questioning. It was apparent that one of the students understood how to develop a question and then determine how to test the question during the investigation. She was asked,” What is a question you could ask about the feather?” She replied, “Why does the water stay still on the feather and doesn’t fall off?” Then I asked, “How could we find the answer to that question?” She didn’t respond. However I only gave her three seconds of wait time. The students interviewed all answered no to the question, “Do you know what observing means?” So I explained, observing was seeing things and noticing changes. Then I used the brine shrimp observation as an example of observing. Then students were able to describe some observations. Overall I was able to get more words out of my students. However, they did not answer the questions about how they could improve their learning with any significant responses. The question did not produce the responses I needed. The lower achieving students had the most difficulty answering but did show improved understanding. The wait time I allowed them may have been a factor in their answering. The interviews indicated that the skill of developing a question was most difficult. The structure of my questions needed to be more precise and I needed to follow the script carefully. The students need to have the expectations very clear so they are able to be successful at the task.

The improvement of the interview would include wait time built into the interview; sharing examples of answers to my questions, yet in a way that doesn't guide students to give identical answers; relating the questions to something in their lives; and adding questions that may extend their thinking. I will be discussing more of the implications for instruction in the next section of this paper.

Content Assessment

The content test for my students was given to measure their knowledge of content regarding living and nonliving things, plants, animals, life cycles and definition of related terms. I gave the test before the treatment and then again at the end of the treatment. All students were read the test aloud and 18 students completed the test during a class period. Two students did not complete the test and one student was dropped from the study because she was transferred to a different school after treatment had started. Consequently there were only 17 test scores to collect for data analysis.

The average pretest score was 33% with the highest percentage of correct responses of 65% for one student. The lowest score for the pretest was 1% correct or 2 out of 20 points. The item analysis for items 1-4 in the pretest showed 65% of the students were able to complete the vocabulary section correctly. This score was higher than the post-test that indicated only 31% of students completed the section correctly.

The average score for the post-test was 14.5/20 or 72%. The students' individual test scores show that 76% of the class scored 50% or below on the content pretest, compared to only one student out of 17 scored below 50% on the post-test. The highest score for the posttest was a 90% for one student. Also the score showed that 94% of the tested students scored a 65% or better on the post-test.

Table 11
Pre-Test/ Post Test Findings Item Analysis (N=17)

Test Item	1-4	5-6	7	8	9	10	11
% of correct Responses Pre Test	9/17 52%	0/17 0%	3/17 17%	2/17 11%	3/17 17%	1/17 5%	1/17 5%
% of correct Responses Post Test	5/17 29%	2/17 11%	14/17 82%	9/17 52%	9/17 52%	10/17 58%	12/17 70%

The post-test shows an overall that 16 students out of the total of 17 tested improved their overall score on the content test. Students showed a decrease in the number or correct responses to items 1-4. Students seemed to have hurried through the beginning portion of the test that may have caused the large drop in the score for this section. The first four items are matching vocabulary to a picture. However the students showed improvement in their scores on all other test items. The most dramatic changes were seen in items 7 and 11. The item 7 answer reflected students' ability to write a sentence about why a plant might survive in poor soil. For item 11 students had to label and draw the life cycle of an insect. It appears students were more comfortable and able to complete these items after treatment.

<u>Case Study</u>

I selected six students from my class to include in my case study. Each student was picked from the bottom middle and top of the class in composite score rating for fall of 2011 based on the DIBELS Next Monitoring system. These tests are designed to predict students' future success on state testing. I included two girls and four boys.

The first student was a boy (754). He is American Indian and had a composite reading score of zero in the fall. He was ranked the 2nd lowest in the class out of 20 students. In the winter his reading score was 21 that showed a growth of 21 points. He is ranked 20th in the class. His pre-test in content showed a score of zero and the post-test was a 70%. His confidence survey pre-treatment was 58% and post-treatment was 75%. He had a change in item # 6 *I am good at writing or drawing about my thinking* while initially choosing "not much" he chose "often" in the end survey. Likewise he made the same change for item #8 *I think I will be able to learn science in 2nd grade.* For item # 1 *I am good at observing* he went from "often" to "not much" showing a decline in his confidence with observing.

The second student was a girl (842). She is American Indian and had a composite reading score of 107 in the fall. She was ranked 14th in a class of 20. In the winter her reading score was 157, a growth of 50 points. Her pre-test in content was 40% and post-test was 65%. Her confidence survey pre-treatment was 54% and post-treatment was 70%. She had a change in her response to item # 2 *I am good at noticing similarities and differences."* On the pre-survey she marked "not much," and post- survey "often". She also had a decline in her confidence about item #1 *I am good at observing* she began at "sometimes" and post- survey chose "not much".

The third student was another girl (121). She is American Indian and had a composite reading score of 115 in the fall. She was ranked 13th in the class of 20. Her winter score was 195 showing and improvement of 80 points. Her pre-test in science content was 25% and post-test was 75%. Her confidence survey pre-treatment was 50% and post-treatment 79%. The most significant change in her confidence response was with items #1, #3, and #5. She originally marked “not much” for all three choices. She ranked them in the post-treatment survey as “often”. This shows an increase in her confidence in observing, asking questions and explaining her thinking.

The fourth student was a boy (373). He is a non-Indian student had a composite reading score of 130 in the fall. He was ranked 12th in his class out of 20 students. His winter reading score was 230 with an increase of 100 points. His pre-treatment science content score was 55% and his post-treatment score was 75%. His confidence survey showed a decline in confidence with a pre-treatment survey of 75% and post-treatment of 70%. The results across items were mixed. For example, his confidence survey item #2 *I am good at noticing similarities and differences* changed from “sometimes” to “often,” yet he also marked item #3 *I am good at asking questions* as “sometimes” on the pre-survey, but “ not much” on the post-survey.

The fifth student was a boy (389). He is an American Indian with a composite reading score of 154 in the fall. He ranked 10th in a class of 20 students. His winter reading score was 227. This is an increase of 73 points. His pre-treatment science test was 10% and post-treatment was 65%. His confidence survey showed a decline in his confidence rating from 87% to 75%. The most significant change to his survey was item

7 *I am good at predicting why something happens during science activities.* Initially he ranked this item as “often” pre-treatment and “not much” post-treatment.

The sixth student was a boy (376). He is a non-Indian with a composite reading score of 179 in the fall. He is ranked 7th in a class of 20. His reading score in the winter was 256. This showed an increase of 77 points. His pre-treatment content science score was 35% and post-treatment was 85%. He had a confidence scoring of 95% pre-treatment and a post-treatment score of 91%. His end survey showed the most significant change for his confidence was with item #7 *I am good at predicting why something happens during science activities.* He initially marked “often” but his end survey showed he chose “not much”.

The case studies indicated that the focal students improved confidence in science skills does not always mean and increase in test scores. Some students improved their scores on the science content test but still had lower or decreased confidence scores. For example, of the three students who scored themselves at 100% in confidence, all had already scored themselves highly in confidence in the pre-treatment survey. In other words they had confidence in their abilities to do the learning before and after treatment. I maintain that higher confidence can be a predictor of success in content learning but it does not guarantee success or learning. Some of the case studies show that the students increased their knowledge but showed a lowering of their confidence to use skills in science. This is puzzling, but perhaps students need to be made aware of their improvements more often. I could easily have shown the students the tests and growth they had made in science learning.

Teacher and Student Reflections

Throughout this study I kept a teacher journal to help collect information about how progress of my students and the changes needed to make the study a better fit for my students' instructional needs. I had challenges due to scheduling, outside interruptions, absenteeism and pacing. I gathered information about the students understanding of the surveys and probes. After reflecting upon my initial interviews with students I found the questions I was asking were confusing and misleading. For example, in response to "Can you think of a time when you might observe something?" the students produced answers like " when it's ten o'clock" or "twelve o'clock". These notes and observations allowed me to recognize the students thought I was talking about the time instead of observation. Also reflecting upon the probe allowed for a better understanding that the students didn't comprehend that a tree was a plant and also that plants produce food.

Observational Rubric

The treatment I designed included a component for teacher observation of students. I designed this rubric based on Wynne Harlens' Process Skill Indicators (Appendix B). This rubric outlines the behavior students may display during an investigation. These behaviors are not strictly visual and therefore difficult to assess by observation only. However when I adjusted my instruction I was able to have students provide evidence of their thinking and the use of the process skills of observing, questioning and communicating. While students were engaged in the inquiry activities I noticed that most students were able to use their senses to observe a phenomenon. They may have noticed similarities and differences but in order determine if they had I had to question them directly during the investigation. For example the students were comparing plant seeds. I asked, "What do you notice?" They responded with "this seed is tiny" "this seed is flat". I asked them to compare with the sentence "I see that this seed is ______while this seed is not ________." They had a more difficult time with the language than with the comparison. When assessing their abilities to question I asked them to write a question about their investigation. We were examining a feather to see what happened when we added water with an eyedropper. Eight out of twelve students responded with a question about the origin of the feather. One student asked, "Why does the water make a bubble?" Together as a class we developed a question, "Why does the water roll off the feather?" Then we talked about whether the question was testable or if it could be answered another way. The third area that the rubric measured was communicating. The students were able to collect information about the bean plant during the bean investigation. I did present the idea of finding information about beans. I did not allow them to think of this on their own. I choose a method of recording for them. However the focus of the bean investigation was the observation of changes. The indicators are a way of marking the further development of process skills. This rubric was an effective way to guide my instructional design.

INTERPRETATION AND CONCLUSIONS

In conclusion, I have found that close observation and data collection can provide data to gauge my instruction as well as describe the students' understanding of the expectations and goals of instruction. In this section I will describe and illustrate each posed research question, my data collection and the interpretation regarding what I have learned as a result of this study.

Research Questions:

Question #1:

In what ways does teaching and development of the process skills of observation, questioning and communication affect students' self-confidence in learning science? Data was collected for this research question using pre and post surveys, student interviews and teacher observation and reflection using journal entries. The surveys indicated that students' attitudes were more positive about being able to use the process skills of observation, questioning and communication. Survey question #1 and #2 refer to observing. Item #1 showed a small decrease in students' confidence in observing. This trend was also evident in the interviews because students were not able to explain what observing meant. I was surprised that they were not able to recognize that they were observing and hypothesizing about their observations. They rated themselves as better at noticing similarities and differences, rather than observing. I noted in my teacher journal, that students were not aware of their observing. They were participating in observation but didn't seem to recognize their experience.

Also as discussed earlier students were not able to explain the value of questioning during the interviews. It was most confusing for them. Even with the changes to the interview questions students needed more support in understanding the value of questioning in the learning of inquiry.

During the interviews most students could reflect upon their ability to record data and make written observations. During the feather observation, I noted in my journal that students were making observations but lacked the skills to write the observation in a sentence. We started observing by using words and the sentence stem, "I notice that…______". Students were also asked to write a question about the feather. Most responded with asking where the feather came from. I used these questions to model the use of questioning in inquiry. However, they did not have enough practice in order to further develop the skill of questioning.

<u>Question #2:</u>

What do students say will be the most helpful things for teachers to do to improve their learning by using observation, questioning and communicating?

When included in an interview, this question was hard for the students to understand and I was only able to get one response besides "I don't know". The student responded to my question *"What would be the best way I could help you learn science better?* He responded, "Sometimes you go too fast and I can't keep up". So I asked him if he needed me to slow down during instruction. He agreed. The other students all responded to this question with an "I don't know," and they also were not able to describe any ways they could "get better" at science. I changed the question in the final interviews by simplifying the wording to *"What part of science do you think you are good at?" and "Which part would you like to get better at?"* The students chose one thing like, "drawing" or "writing."

<u>Question #3:</u>

In what ways does teaching and development of the process skills of observation, questioning, and communicating affect the students' learning and understanding of science content?

The content test did show an improvement with 94% of the class scoring 65% or better on the post treatment test, compared to one student scoring at this level on the pretest. Results from use of the formative assessment probe also showed students had a better understanding of the content covered regarding the attributes of living things. In contrast to this result, the section of the content test on living and non-living things was the only section for which the students' scores showed a large decrease.

The research indicated to me that science as "practice" has become more important as part of the instruction when teaching science. The *Framework for Education Standards*, (NRC, 2012) and the *21st Century* Skills (P21, 2011) frameworks both support the teaching of content and skills together using an inquiry model for instruction. The NSES, CSMEE both support the use of inquiry to design and conduct investigations. Also the NSTA defines inquiry as a best practice. The State of Montana Standards and Hardin School District Standards have included inquiry as an instructional model for the science taught in all grade levels. In order for inquiry instruction to be most effective teachers will need professional development and a better understanding of formative assessment practices. As I planned my study I had completed course work on formative assessment and had received inquiry training at the Exploratorium in San Francisco, CA. I was feeling confident enough to use this lesson structure to teach science and process skills in my classroom. The biggest challenge I faced was finding time to give students the practice of observing, questioning and communicating.

Our school currently has restrictions on our instructional time. We have 90 minutes of whole group reading instruction, 60 minutes of individualized reading instruction, and two math blocks of 20 and 60 minutes. These are sacred times. They cannot be used for any other content. Together these take three hours and 40 minutes. Recess and lunch account for 80 more minutes. Then students will have from 30 to 60 minutes with a special class such as music, gym or library. This leaves about 30 to 60 minutes for science and social studies instruction. I wasn't able to use any of this time to complete the science activities. This created two issues in my study as it meant that the amount of content I was able to cover was less, and that students were not able to become more proficient at using inquiry. Most educators would agree that students need more practice to improve proficiency.

A more effective way would be to be able to overlap the science content and inquiry within the reading, writing and math instruction. Given the opportunity I would like to use inquiry to teach math. I believe the process skills of observing; communicating and questioning along with other problem-solving skills would make an excellent model for instruction in many subject areas. Inquiry seems to have a balance between discovery and direct instruction. It begins with the making of observations, developing questions, followed by formulating investigations to test questions, then sense making, and sharing the information learned. Clarification of science content is provided to students through direct instruction. The formative assessment also allows for the discovery of students own thinking, misconceptions and this is powerful way to drive instruction. The information in this study's findings may be of interest to fellow educators, including teachers in training at college and university levels. Not everyone will be as fortunate as me in getting the opportunity to learn inquiry from the Exploratorium, but the insight and wisdom of the inquiry model can be learned and practiced, and inquiry is a possible pathway to making connections in learning instead of separating subjects into "blocks" of instruction.

Any reflection on using the information from this study to improve my instruction must begin with a discussion of wait time. I needed to allow at least ten seconds when asking a question. Also I needed to teach for understanding. I know that explaining something orally didn't provide the best understanding for students. They needed to first have an experience to attach meaning to the information expressed. This was the cornerstone to the study. The process skills of science are just as important as the content. They cannot be separated and still used as a best teaching practice. I made changes to the survey prior to treatment in order to included questioning skills. I also taught the meaning of the words observe, and predict. I identified the skills of observing, questioning and communicating the skills using science content. I worked to provide practice in science inquiry. This was an attempt to improve students' attitudes and science confidence by experiencing success during their inquiries. Once students had a clear understanding of process skills they were be better able to manipulate, construct and define the science content in relation to living and non-living things. This success in learning will create more science confidence in students.

Lessons for Teacher Researchers

In order to improve the data collection for this study I would encourage teachers to work with a team approach to observing students as well as having the teacher observed to provide specific feedback and collaboration. The teacher may want to have a co-teacher use the observational rubric to observe students during an inquiry investigation. This could be repeated many times to help create a resource of instructional planning and providing scaffolding of instruction in inquiry behaviors. Each process skill could be observed using the "indicators of development of process skills" worksheet provided by the Institute For Inquiry. The goal of the observation should be specific in order to provide meaningful observations. The teacher researcher should also reflect upon the instruction of inquiry and open a discussion with fellow teachers about how to provide students with the best support to inquiry learning.

Some of the data collected from this study was found in the interview given between the student and teacher. In order to uncover the most information the interview must be paced to meet the needs of students. The questions need to be designed to illuminate students' ideas and thoughts, perhaps giving students a set of scenarios from which to choose (for example, the scenario that illustrates someone asking a question, making an observation or communicating ideas). Once students become more familiar with the language of inquiry they will be able to recognize and identify the skills used in inquiry. Also it is imperative the students are allowed time to think and reflect before they give an answer during an interview. The interviews should be short and to the point with time allowed for elaboration and posing questions that may extend students thinking. The interview can be a powerful tool for gathering information about students' ideas and misconceptions about science content.

While collecting data, the survey that I used was designed based on a self-confidence survey used to describe the attitudes associated with science learning. This survey didn't illustrate any significant change in students' attitudes. It could be simplified further in order to have students give a general rating rather than using a complete list of attitudes in the individual surveys. For example, students could rate themselves with a yes or no response after participating in a class inquiry, discussion, or direct instruction lesson. “*I feel that I was good at noticing details in the observation of the birds nest”(Yes or No).* This kind of survey would give immediate feedback. Students would also learn to think about their attitudes about learning science. The change in attitude is important for instruction because improved attitudes may create more confidence in learning.

VALUE

As I began this journey with this study I was excited and enthusiastic about the possibility that I may have some knowledge to offer as a professional educator. I’ve been in the classroom for 22 years and counting. I love to be in charge. Top Dog. I also love talking to kids every day. They make life a learning experience always. I have learned so much from each student that has passed my way. I can only hope they have learned from me. Like many teachers I came upon teaching because I wanted to always learn and to be around children. I still love learning. I always want to improve, and become better. I wanted to see the face light up when they finally get it. Sadly, the world of educating has changed it’s about test scores, adequate progress and achievement. However, I also believe that change is a personal experience. Change can be much more meaningful when it comes from the person who wants to change and it is not forced upon them.

My voice as an educator has been somewhat silenced by the expectations put upon me. I am told how to teach, what to teach, and for how long to teach. Even if I have enough expertise to identify weaknesses with this way of thinking I do my job the best that I can.

Because I was given an opportunity to learn the inquiry model of instruction for science education at the Exploratorium I was overjoyed at the possibilities it presented. It seemed to make perfect sense to me. This was the way to teach science. I could do this. So it came to be I would make my best effort to design a study that would be based upon Wynne Harlens' research and use inquiry to teach science. The actual teaching was very fun. I remember when one student said to me, "When are we going to get to talk to a real scientist?" He was tired of hearing that a scientist has to answer some questions for us. I wanted to say, "you are a real scientist, what do you think?" When designing the study I followed what research said was best practice. I still think that inquiry can be used across the curriculum. My teaching is better and more effective because of what I learned in this process.

I still maintain that this was a success because I learned as much as my students did if not more. One thing I have learned is that a belief is powerful. I know it is as true for adults as for students. If you believe you can do something then generally you are right. I need to remember this truth every day. What I believe about my world is true today.

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APPENDICES

APPENDIX A

INQUIRY CONTINUUM

Montana K-12 Content Standards and Performance Descriptors for Science – Inquiry Continuum

Adapted from National Research Council *Inquiry and the National Science Education Standards*, Washington, DC: National Academy Press, 2000

Essential Features of Classroom Inquiry and Their Variations

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

More ← **Amount of Learner Self-Direction** → **Less**

Less ← **Amount of Direction from Teacher or Material** → **More**

APPENDIX B

PROCESS SKILL OBSERVATIONAL RUBRIC

Based on “Indicators of Process Skill Development” Institute For Inquiry (2011)
www.exploratorium.edu/ifi

Observation	Questioning	Communicating
Identify obvious differences/similarities	Ask a variety of questions investigable and non investigable	Talk freely making or not making a record?
Make use of senses during in exploring objects and materials?	Participate in discussing how questions can be answered?	Listen to others ideas and their results?
Identify differences of detail between objects or materials?	Recognize differences between investigable and non investigable? *	Report events in drawings writing, models, and paintings?
Identify points of similarity between objects when differences are more obvious than similarities?	Suggest how answers to various questions can be found?	Use tables, graphs, and charts to record and report results when suggested?
Choose to use aides (such as lens or tool) for study of details as necessary?	Choose a realistic way of measuring or comparing things to get a result?	Use information from books or other resources to check or supplement their investigations?
Distinguish from many Observations those which are relevant to the problem at hand?	Help in turning their own questions into a form that can be tested?	Choose a form for recording or presenting results which is both considered and justified?

APPENDIX C

SELF-CONFIDENCE SURVEY

Name ______________________________ Date _____________________________________

This survey is for my information only. You may choose not to answer any questions you don't want to answer. I feel that...

1. I am good at observing.	Often	Sometimes	Not much
2. I am good at noticing similarities and differences.	Often	Sometimes	Not much
3. I am good at asking questions.	Often	Sometimes	Not much
4. I am good at following science safety rules.	Often	Sometimes	Not much
5. I am good at explaining my thinking.	Often	Sometimes	Not much
6. I am good at writing or drawing about my thinking.	Often	Sometimes	Not much
7. I am good at predicting why something happens during science activities.	Often	Sometimes	Not much
8. I think I will be able to learn science in 2nd grade.	Often	Sometimes	Not much

APPENDIX D

IS IT LIVING PROBE

Is It Living?

These questions are for my information only. You do not have to answer any questions that you do not want to answer.

Listed below are examples of living (which includes once living) and nonliving things.

Put an X next to the things that could be considered living.

___tree

___rock

____fire

___wind

___rabbit

____cloud

____grass

____seed

_____hibernating bear

____egg

____Sun

____boy

____mushroom

____potato

____leaf

___butterfly

___fossil

____river

Explain your thinking. What rule or reasoning did you use to decide if something could be considered living?

____

____

____

APPENDIX E

SCIENCE UNIT TEST

Name ______________________

A
Unit Test

Unit A Test

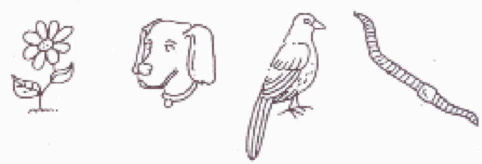
Reviewing Vocabulary

Use a word from the box to complete each sentence.

adaptation	living things
nonliving things	offspring

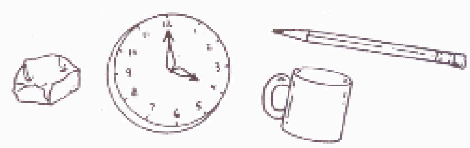
1. Picture A shows different kinds of
_____ _____ _____.

A

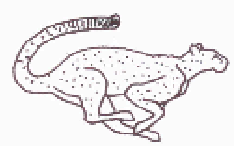


2. Picture B shows different kinds of
_____ _____ _____.

B



3. The long tail of this cheetah is an example of an
_____ _____.



4. The babies of this cat are called its _____ _____ _____.

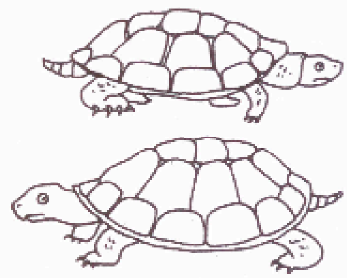
Name ______________________________

A
Unit Test

Checking Main Ideas

Circle the letter of the best answer.

5. The animals in the picture are



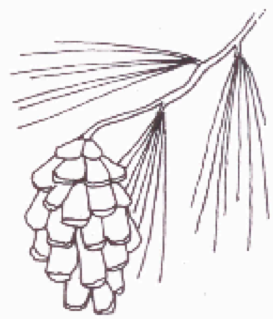
A amphibians

B fish

C mammals

D reptiles

6. Which is a step in the life cycle of this plant?



A making flowers

B pupa

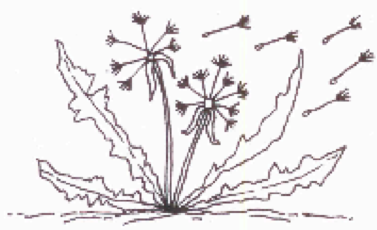
C making seeds

D larva

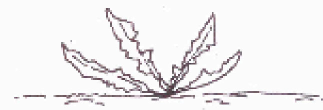
Name ___________________________________

A
Unit Test

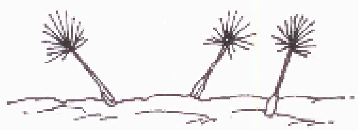
9. Use Numbers The pictures show the life cycle of a plant. Write a **2, 3,** or **4** below the other stages to show the correct order.



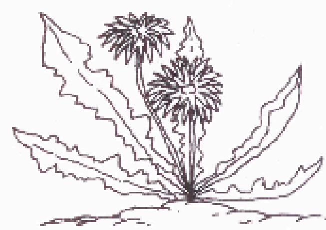
____



____



__________1__________



____

10. Compare How are these animals alike? How are they different?

____

____

____

____

Name ______________________

A
Unit Test

Organizing Concepts

11. Complete the life cycle. Write the names of the steps.