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Assessment of a High School Geological Field Course

By

Eric Morgan Ruckert

A Report

Submitted in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE IN APPLIED SCIENCE EDUCATION

Michigan Technological University

2009

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This report, Assessment of a High School Geological Field Course, is hereby approved in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN APPLIED SCIENCE EDUCATION at MICHIGAN TECHNOLOGICAL UNIVERSITY.

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Abstract

Assessment of a High School Geological Field Course

Fieldwork is supportive of students' natural inquiry abilities. Educational research findings suggest that instructors can foster the growth of thinking skills and promote science literacy by incorporating active learning strategies (McConnel et al, 2003). Huntoon (2001) states that there is a need to determine optimal learning strategies and to document the procedure of assessing those optimal geoscience curricula. This study seeks to determine if Earth Space II, a high school geological field course, can increase students' knowledge of selected educational objectives. This research also seeks to measure any impact Earth Space II has on students' attitude towards science.

Assessment of the Earth Space II course objectives provided data on the impact of field courses on high school students' scientific literacy, scientific inquiry skills, and understanding of selected course objectives. Knowledge assessment was done using a multiple choice format test, the Geoscience Concept Inventory, and an open-ended format essay test. Attitude assessment occurred by utilizing a preexisting science attitude survey.

Both knowledge assessments items showed a positive effect size from the pretest to the posttest. The essay exam effect size was 17 and the Geoscience Concept Inventory effect size was 0.18. A positive impact on students' attitude toward science was observed by an increase in the overall mean Likert value from the pre-survey to the post-survey.

Chapter 1

Earth Space II, a field course for high school students, originally began in the summer of 2006 in coordination with Mr. Kevin Kapanka from Kenton High School in Kenton, Ohio. Both Mr. Kapanka and I were members of the Teachers Earth Science Institute (TESI), an elective course in the Master's of Applied Science Education (MSASE) program at Michigan Technological University (Michigan Tech). TESI was designed to give teachers the ability to learn about mining and mine engineering. TESI was setup to be inquiry-based with the majority of time dedicated to outside activities. It is from the TESI experience that we derived an idea for a summer field course for high school students.

It was my goal to give students the chance to participate in a hands-on summer course, which would allow them to use the knowledge that they acquired taking Earth Space I during the academic year in high school. Earth Space II would also give the students the ability to travel, experience their natural environment, and to learn about natural resources.

The State of Indiana course description for Earth Space Science II is an elective extended laboratory, field, and literature investigations-based course whereby students apply concepts from other scientific disciplines in synthesizing theoretical models of Earth and its interactions with the macrocosm (ISBE, 2008). The Earth Space II course at West Noble High School is designed to be a continuation of the Earth Space I course which the students have taken in the regular high school academic year. As part of Earth Space II students travel from West Noble High School in Indiana to Copper Harbor in Michigan. As students travel they participate in lectures, read literature on mining,

complete outdoor laboratories, complete a daily workbook, have evening discussions about the day's events, and complete a nightly journal. Earth Space II gives many of my students their first real field course experience. The knowledge and experience gained by such an intense field course can benefit these students for the rest of their lives.

Since the state of Indiana intends Earth Space II to be an extension of the knowledge that students have acquired in Earth Space I it does not give Earth Space II its own content standards. Indiana State Standards for Earth Space I that will be covered in Earth Space II are:

- ES. 1. 19 Identify and discuss the effects of gravity on the waters of Earth. Include both the flow of streams and the movement of tides.
- ES. 1. 20 Describe the relationship among ground water, surface water, and glacial systems.
- ES. 1. 22. Compare the properties of rocks and minerals and their uses.
- ES. 1.23 Explain motions, transformations, and locations of materials in Earth's lithosphere and interior.
- ES. 1. 25. Investigate and discuss the origin of various landforms, such as mountains and rivers, and how they affect and are affected by human activities.
- ES. 1. 27. Illustrate the various processes that are involved in the rock cycle and discuss how the total amount of material stays the same through formation, weathering, sedimentation, and reformation.

In addition, as part of this course students learn the unifying themes that are required by the Indiana State Science Standards. The unifying themes stated in the

Indiana State Science Standards (ISBE, 2000) are the Nature of Science and Technology, Scientific Thinking, and Mathematical World.

The inquiry standard for the National Science Standards (NRC 1996) has similar requirements for students which are that students have the abilities necessary to do scientific inquiry, have the opportunity to use scientific inquiry, ask questions, and use appropriate tools and techniques to gather data. A traditional classroom setting can introduce these ideas; however, only an intensive hands-on experience such as a field course can really give the students a true opportunity to use and understand these standards.

Variable Definition

The purpose of my study is to determine if Earth Space II has increased students' knowledge of the listed educational objectives. This research will also seek to measure any impact Earth Space II has had on students' attitude towards science.

The independent variable is the presentation of the material in the format of a field course, Earth Space II. The dependent variables are the student's knowledge of the stated educational objectives and the students' attitude toward science. Student knowledge of the stated objectives will be assessed based upon two pretests, two posttests, responses to questions in student nightly journal, and comments made in student workbook/journals. Impact on students' attitude towards science will be assessed using a science attitude survey. Kind (2007) clarifies attitude by stating:

> A common definition has involved describing attitudes as including the three components of:

1. a knowledge about the object, the beliefs, ideas component (Cognitive);
2. a feeling about the object, like or dislike component (Affective);

   and
3. a tendency-towards-action, the objective component (Behavioral)

   (Kind et al., 2002, p873).

Since I agree with Kind's definition of attitude I decided to use the survey that was developed to match this definition. Kind (2007) included some items from the Relevance of Science Education questionnaire, the 2003 Programme for International Student Assessment (PISA) questionnaire, and items from the attitude to science for 5-11 year olds developed by Pell and Jarvis.

Research Questions

1. Will Earth Space II positively change participants' knowledge of the selected Indiana Science Standards given that it was "optimized for learning" (Huntoon et al., 2007)?
2. Will Earth Space II positively change participants' attitude towards science with respect to the 8 components of attitude (Kind et al., 2002)?

Assessment Tools

The dependent variables were measured using both quantitative and qualitative data. Quantitative data consisted of two separate pretests and posttests on knowledge and a pre-survey and post-survey of attitude (Appendix A).

Qualitative Data was collected utilizing students daily workbooks and nightly journals. A teacher's daily journal was also kept.

Hypothesized Results

It is my thought that a field course can provide opportunities for the student to develop one or more of the traits of scientific literacy. Daily activities in the field can be designed to expose the students to new and exciting situations giving the chance to use and construct scientific knowledge. An increase in scientific literacy and an internalization of the field course experiences will foster a deeper understanding of geoscience concepts. This increase in geoscience concepts and scientific literacy will result in a positive increase in the students' knowledge of the selected Indiana state standards.

I also think that the exposure of students to new and exciting situations will actively engage the students. This active engagement will results in an observable increase in students' attitude toward science.

Possible Effect of this Research

Field work itself is supportive of students' natural inquiry abilities. Educational research findings suggest that instructors can foster the growth of thinking skills and promote science literacy by incorporating active learning strategies into the classroom (McConnel et al, 2003). Huntoon (2001) states that there is a need to determine optimal learning strategies and a need to document the procedure of assessing those optimal geoscience curricula. It is my intent that careful assessment of the course objectives will provide new data on the impact of field courses on high school students' scientific literacy, scientific inquiry skills, and understanding of selected course objectives.

The data from the attitude survey will also provide additional information on high school students' attitude toward science as a result of participating in an optimized learning strategy (Huntoon et. al., 2001) like Earth Space II.

Chapter 2

What impact can a nine day summer field course have on students' knowledge and attitude toward science? The goal is to have the student come away with a greater understanding of the course objectives and a more positive attitude toward science. These criteria may seem trivial, but in reality, most field trips can be summarized as adventure-social events (Orion, 1993). How much material and in what format should the course material be presented so that students are given the opportunity to achieve the goal of greater understanding and increased positive attitudes? Obviously nothing of such a detailed nature as would satisfy a field geologist or any other field specialist should be attempted (Miller, 1913). The course material should be thoughtfully planned and focused to accommodate the field environment.

The careful planning of a field course starts before the first student arrives for the trip. The curriculum of the course should be designed around several key concepts, such as scientific literacy, scientific inquiry and understanding. The first part of the question, how much, should be driven by the second part, what format. If a teacher is seeking a higher cognitive level of understanding then more time will have to be devoted to the activities and less material presented.

Field Courses

The geosciences lend themselves to field work. Like most geoscience majors I was required to complete a field course before graduating college. When polled alumni at Southwest Missouri State University agreed that field courses are of great importance for the development of a field geologist (Plymate et al, 2005). Field work itself is

supportive of students' natural inquiry abilities. Educational research findings suggest that instructors can foster the growth of thinking skills and promote science literacy by incorporating active learning strategies into the classroom (McConnel et al, 2003). Despite the potential for successful learning, however, the field trip (as even a small component) in introductory science courses are uncommon (Elkins J. & Elkins N., 2007). Why is such a seemingly essential component of the natural sciences so neglected? Field trips are often avoided for a variety of reasons including logistics, instructor's unfamiliarity with conducting field trips, and the lack of curriculum materials relevant to field trips (Orion, 1993). Even though these may be legitimate concerns they do not excuse the removal of such an authentic instructional tool from the curriculum.

Several journal articles (Elkins J. & Elkins N., 2007; Huntoon et al. 2001; Mogk, 1997; Orion, 1993) have been published to give teachers a basic outline of how to design, implement and assesses an effective field course. Of these Orion's (1993) article focuses most effectively on the planning of field trips. Orion and Hofstein (1991) identified three variables that impact student learning in the field. These three variables are connected to student characteristic prior to the field trip: a) knowledge level and type, b) acquaintance with the field trip area and c) psychological preparedness. All together these variables define a novelty space for the student getting out on a field trip. (Orion & Hofstein, 1991) Orion (1993) states that if the student has too much novelty, meaningful learning is not likely to occur on a field trip. Many teachers have suffered the pain of seeing their field trips turn into a social outing. Focus of the field trip must be set prior to leaving the classroom. Orion suggests a three part module comprised of a preparatory unit, a one-

day field trip, and a summary unit. (Orion and Hofstein, 1991.) This module format can be applied to a multiple day field course.

Successful examples of field courses in the literature (Elkins J. & Elkins N., 2007; Miller, 1913; Huntoon et al,, 2001) use the idea of giving a unifying question and didactic lecture each morning before field work starts, then concrete field experience during the day, and a follow up discussion and/or summary journal activities in the evening. By following this module routine the longer field course can avoid falling into the realm of social outings by giving the students the structure needed to have knowledge gains and develop a positive attitude toward science.

Even with Orion's module and the growing awareness of the need to reform the geoscience education system there are relatively few cases in which "reformed" education and its measured effectiveness have been presented to the geoscience community (Huntoon et al., 2007). This lack of quantified impact on students learning hinders a teacher from utilizing a field course as part of a science curriculum. It is my intent that careful assessment of the course objectives will be conducted to provide new data on the impact of the proposed field course on students scientific literacy, scientific inquiry skills, and understanding of selected course objectives.

Scientific Literacy

The goal of any science teacher is to give our students the inspiration to stay current and engaged in science throughout their life and thus be called "scientifically literate".

If teacher is going to produce a student that is to be scientifically literate then a clear definition of science should be made. The definition of science usually focuses around a method of investigation that eliminates and controls variables that allows for a clear unbiased answer to a question. Tarbuck and Lutgens (2006) define science as being based upon two assumptions. First is that the natural world behaves in a consistent and predictable manner. Second, through careful, systematic study, we can understand and explain the natural world's behavior. In other words, science is the pursuit of knowledge and understanding through the use of the scientific method.

Literacy, which can be considered as a thought process, is the second term in scientific literacy. Literate thought is the conscious representation and deliberate manipulation of (the thinking involved in reading). Assumptions are universally made; literate thought is the recognition of an assumption as an assumption. Inferences are universally made; literate thought is the recognition of an inference, of a conclusion as a conclusion (Olson, 1994, p 240). The definition of literacy as a process makes the definition of scientific literacy appear clearer.

If you determine science as being the body of knowledge constructed through a process and literature as the process of internalizing and using that knowledge then this would seem to fit with the definition of scientific literacy that we will see when we review the standards.

Science Literacy in the standards. The most practical and influential source of a definition of science literacy comes from the state and national science standards. Both the Indiana and Michigan benchmarks were based upon the Science for All Americans: A

Project 2061 Report on Literacy Goals in Science Mathematics, and Technology (ISBE, 2000; MDE, 1996). Science for all Americans (AAAS, 1990) gave teachers and schools a narrative account of the knowledge and abilities that make up science literacy (Zemelemen et. al. 2005, p 143) Indiana Department of Education has not set forth a definition of scientific literacy in the science standards, instead the science standards are used to define the term. A common theme approach is used in the K-8 standards. These common themes are based on seven standards, Nature of Science and Technology, Scientific Thinking, Physical Setting, Living Environment, Mathematical World, and Common Themes. The Historical Perspective standard is added to the K-8 Standards in seventh grade (ISBE, 2000). Each of these standards is further defined based upon grade level and the expected ability of the students. To keep consistent the Indiana Standards provide a basic introduction to the standards at the beginning of every grade level.

The Indiana Standards change format in high school. Each subject area has two standards, based on principles of the subject area and historical perspectives of the subject area. Ideas listed underneath each standard build the framework for the course being taught. The Indiana Department of Education also states that students need to understand that science, mathematics, and technology are interdependent human enterprises, and that scientific knowledge and scientific thinking serve both individual and community purposes (ISBE, 2000). The Indiana Department of Education additionally includes text follows expanding on the historical perspective and principals of the course being taught. When compared to the original seven K-8 standards, the process has taken on a stream-lined approach. The problem that comes with this streamlining is that more emphasis is given to two standards. These two standards,

Principles and Historical Perspectives, then take importance over the remaining standards in all science courses in high school. The streamlining of standards in high school makes sense due to the separation of science into different disciplines such as Earth and Space, and Biology.

The lack of a clear definition of the idea of scientific literacy, explain, and describe in the Indiana State Standards leaves a teacher looking for an alternate document which will offer definitions of these terms. It is possible for an Indiana teacher to use the Michigan State Standards as a model since both the Indiana and Michigan standards were based upon the Science for All Americans: A Project 2061 Report on Literacy Goals in Science Mathematics, and Technology (AAAS, 1993). The Michigan Standards define the terms scientific literacy, explain and describe. Explain refers to the ability to reason why the situation is true or happens and describe is the ability to state how a situation occurs based upon the learned scientific knowledge. Scientific literacy is defined in terms of individuals who are capable of performing the three activities of using scientific knowledge, constructing scientific knowledge, and reflecting on scientific knowledge (MEGOSE, 1995).

The Indiana State standards also share similarity to the national science standards proposed by the National Research Council (NRC) in that scientific literacy is defined by the standards. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities. In the *National Science Education Standards,* the content standards define scientific literacy (NRC, 1996). Like the Indiana standards this type of definition allows for various

definitions of scientific literacy because of a lack of a clear vision or summative statement at the beginning.

The NRC standards do have a redeeming feature, which is the importance placed upon scientific Inquiry. The NRC standards suggest that scientific literacy would be accomplished through the teaching of inquiry. Inquiry is defined as the "process of science" and requires that students combine the process and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science (NRC, 1996). The NRC goes further and lists abilities necessary to do scientific inquiry. These abilities are formulate and test a hypothesis, design and conduct a scientific investigation, use of technology and mathematics, analyze argument with science, and communicate a scientific argument.

Based upon my review of the literature and standards I have decided to use the MEGOSE definition of scientific literacy in this study. The MEGOSE definition is that scientifically literate individuals are capable of performing the three activities of using scientific knowledge, constructing scientific knowledge, and reflecting on scientific knowledge (MEGOSE, 1995). A clear definition of scientific literacy using these three requirements provides focus for designing an effective curriculum for this field course.

Field courses can provide opportunities for the student to develop one or more of the traits of scientific literacy. Daily activities in the field will be designed to expose the students to new and exciting situations giving the chance to use and construct scientific knowledge. The students will be asked to complete summary questions at the end of the day as part of their journal writing, thus reflecting on their newly acquired scientific knowledge. These summative questions will also ask the student to describe, explain

and/or use what they have experienced during the day. Assessment of the students' growth in scientific literacy will be measured utilizing an essay exam, which utilizes the nightly journal questions as assessment items. As students increase their scientific literacy and are asked to internalize their experiences a deeper understanding of the geoscience concepts will occur.

The goal of all teachers, even those teaching a field course, should be that their students will have a deeper understanding of the course material. Traditional education is based in large part on the blank slate: children come to school empty and have knowledge deposited in them, to be reproduced later on tests (Pinker, 2002). This idea of learning leads to didactic teaching methods that make the teacher the giver of knowledge and the students the receivers. Elkins (2007) notes that this type of didactic teaching in introductory geoscience course is not effective at improving conceptual understanding of geosciences concepts among students that participated in these courses. This one-sided view of learning is in sharp contrast to the cognitive theory of education.

Placed within the context of information processing, cognitive psychology is the study of how man, collects, stores, modifies, and interprets environmental information or information already stored internally (Heckman, 1993). Cognitive psychology was revolutionary in its ideas about how the mind learns, instead of looking at the behavior, psychologist tried to look at the brain itself. The idea that learners actively construct knowledge would lead to the educational teaching strategy called constructivism. "Although Piget did not refer to himself as a "constructivist" until latter in his life, the view is central to his position (Driver et al., 1994). The idea that students are active learners that must construct their knowledge leads instructors to pursue teaching

strategies that engage the students and provides that students with the opportunity to use their existing knowledge. A field courses that gives students the opportunity to observe and describe their natural world provides such an opportunity.

Inquiry

Inquiry can be a powerful tool to promote Scientific Literary. Inquiry is defined by the NRC as including "process of science" and requires that students combine the process and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science. (NRC, 1996) The NRC (1996) states that the essential features of classroom inquiry are that learners are engaged by scientifically oriented questions, give priority to evidence, formulate explanations, evaluate their explanations, and justify their explanations.

The goal of an instructor should be to reduce the amount of teacher directed learning. Activities outside of the classroom are important components to promoting this type of learning. I doubt if anyone can ask more "whys" than a boy in the field (Miller, 1913).

Just taking students outside of the classroom does not guarantee a successful inquiry experience. A lack of domain-specific knowledge may influence the kinds of questions students ask (Chin, 1999). If a student does not have the background knowledge required to complete an activity then frustration or disinterest may occur (Rutherford, 1964). To engage in science inquiry means that the student has enough science background to formulate scientifically meaningful questions. Orion (1993) sites

the need of background information as a key component for the removal of novelty and thus have a successful and educational field trip.

For students to complete an inquiry activity they need to have prior knowledge in the subject area. Due to the need for background knowledge students are required to complete a year of Earth Space I prior to taking Earth Space II. Although Earth Space I does not cover exactly the same information as Earth Space II it does give the students basic introduction to Earth Science.

Inquiry in the geosciences has a unique characteristic, which derives from the involvement with the "experiments" that have already been conducted by nature (Orion & Kali, 2005). Students are asked to spend most of their time formulating explanations for events that have already occurred. A geoscience teacher has the challenge of presenting this evidence to their students for inquiry. This study will utilize the daily field activities to expose the students to the geological evidence first hand, as compared to the more common didactic or technological (pictures, video, etc.) formats.

Student inquiry will be directed and assessed by daily themes. These themes will focus the students on evaluating the geological evidence that have seen and to apply that evidence to answering questions in their workbook. The workbook will give the students a clear articulation of the activities, goals and expected outcomes of the course, an important aspect of a successful field experience (Mogk, 1997). This format places vast importance on students' prior knowledge and cognitive abilities as these will be pivotal in the students' ability to conduct inquiry.

Knowledge and Cognitive Processes

Indiana and other state standards are given to teachers to direct what knowledge is required for students. The standards also are intended to direct how students use that knowledge. Standards therefore need to be classified so that the teacher can clearly determine what teaching strategies should be used and exactly what each standard is intending what the student learn. Bloom's Taxonomy of Educational Objectives is a framework for classifying statements of what we expect or intend students to learn as a result of instruction (Krathwohl, 2002). A Taxonomy table, with knowledge on one axis and cognitive process on the other axis, has been used in Geoscience Courses field courses and other active learning environments (Elkins J. and Elkins N., 2007; McConnel et al., 2007; McConnel et al., 2003; Huntoon et al., 2001). Airasian and Miranda (2002) indicate that a Taxonomy Table is a useful tool for carefully examining and ultimately improving the connection between assessment and objectives. Bloom's original taxonomy was published in 1956 with a revised version of the taxonomy being published in 2001 (Krathwohl, 2002). The Bloom's original taxonomy set to define the levels of cognition in terms of Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. The revised Bloom's taxonomy takes into consideration the advancements in cognitive psychology since the publication of the original taxonomy. Krathwohl (2002) stated that the original Bloom's Taxonomy was revised into a two-dimensional framework consisting of knowledge and cognitive process. The new cognitive process categories are Remember (formerly Knowledge), Understand (formerly Comprehension), Create (formerly Synthesis), Apply, Analyze and Evaluate. They are arranged in a

hierarchical structure, but not as rigidly as in the original Taxonomy (Krathwohl, 2002). The definition of each of these terms and subcategories are given by Krathwohl.

> Remember: Retrieving relevant knowledge from long-term memory. This also includes two sub-dimensions of recognizing and recalling (Krathwohl, 2002).
>
> Understand: Determining the meaning of instructional messages, including oral, written, and graphical communication. This cognitive dimension includes seven sub-dimensions, interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (Krathwohl, 2002).
>
> Create: Putting elements together to form a novel, coherent whole or original product. This cognitive category has the sub-dimensions of generating, planning and producing (Krathwohl, 2002).
>
> Apply: Carrying out or using a procedure in a given situation. The sub-dimensions of executing and implementing help clarify this dimension (Krathwohl, 2002).
>
> Analyze: Breaking materials into constituent parts and detecting how the parts relate to one another and to on overall structure of purpose. Sub-dimensions for this cognitive dimension are differentiating, organizing, and attributing (Krathwohl, 2002).
>
> Evaluate: Making judgments based on criteria and standards. Checking and critiquing are the sub-dimensions for this category (Krathwohl, 2002).

The knowledge component of the revised Bloom's Taxonomy has been divided into four dimensions. They (knowledge dimensions) were reorganized to use the terminology, and recognize the distinction of cognitive psychology that developed since the original framework was derived. (Krathwohl, 2002) Like the cognitive process dimension of the revised Taxonomy, the new knowledge dimensions also contain sub-dimensions. The new knowledge dimensions are factual, conceptual, procedural and metacognitive.

The revised Bloom's Taxonomy allows a specific context for classifying the objectives selected for this project. The revised Bloom's Taxonomy also blends the components of cognition, scientific literacy, and scientific inquiry together. A clear taxonomy table will allow for the course assessments, which are based on the selected course objectives, to be organized and classified based on the desired cognitive processes and knowledge.

In my project assessment of knowledge of geological concepts will be completed using a multiple choice format with the pretest and posttest. The assessment items in this test focus on geological factual and conceptual knowledge. The Geoscience Concept Inventory developed by Libarkin and Anderson (2004) will serve as the basis for my pretest and posttest questions. The Geojourney conducted by Bowling Green University presently utilizes the Geoscience Concept Inventory as its pretest and posttest (Elkins J. & Elkins N., 2007) Libarkin and Anderson (2004) have developed 72 items to measure a student's understanding of geoscience concepts. I have chosen to select only 15 items of the original 72 items due to the limited course objectives and the hindrance of completing long assessment in the field environment. Items selected for the multiple choice format

pretest and posttest will be based upon their alignment with the selected course objectives.

Like the instructors of the Geojourney evaluation of the pretest will not be completed until after the posttest is given, thus limiting the ability to use the pretest as a formative assessment tool (Elkins J. & Elkins N., 2007). The Geoscience Concept Inventory was developed over several years, with question generation and validation based upon a variety of qualitative and quantitative data (Libarkin & Anderson, 2005). Initial data for the Geoscience Concept Inventory was collected using 265 open-ended questions and 105 interviews collected by participating college students (Libarkin et al. 2005). The Geoscience Concept Inventory was given to 2500 students in a study of 43 different geoscience college courses (Libarkin & Anderson, 2005) and thus provides comparative data for other studies on the effectiveness of instruction, on student's conceptual knowledge.

Students' understanding of the selected Indiana state standards will also be evaluated using an essay format pretest and posttest. The items on the essay exam will be presented in the students' nightly journals. Each day will be focused around one or two themes, which are presented in the students' daily workbook and coincide with the nightly journal questions. The students will be asked to answer fill out their daily workbook as they complete their field activities. The nightly journal questions will be answered by the students using the information collected in the daily workbooks. In addition to the workbook and nightly journal the students will be also asked to complete a mineral kit, which will consist of rocks and minerals collected during the trip.

Attitude

Learning clearly has an affective component and developing attitudes is important for students' achievement (Kind et al., 2007). Kelly (1986) states that students' attitude about a course is considered to be one if not the largest factor in their success in that course. Attitudes to science may well prove more lasting when they (students) leaves school than the bits of scientific knowledge they have acquired (Kelly, 1986). Teachers know what it is like to teach a group of students who are actively engaged. This active engagement results in an observable increase in learning. Attitudes not only influence views of science and aspirations for future careers, they can also influence attainment (Jarvis, 2004) Since attitude plays an important role in the success of students in a science class then it should stand to reason that a proper assessment of this factor is needed as well. Studies (Kind, 2007; Caleon, 2007; Jarvis 2001, 2002, 2003, 2004, 2005) have been conducted to develop a valid measure of students' attitudes toward science.

The literature shows recurring complaints and concerns regarding the measurement of science attitude (Blalock et al., 2008). As with any assessment a clear definition of what is being measured is required. For the purpose of this study, Kind's (2007) definition of attitude as the feeling that a person has about an object, based on their beliefs about that object, will be used. Since I have chosen to use the definition of attitude proposed by Kind, the attitude survey developed by Kind (2007) will be utilized in this study. The survey consists of 45 items, which utilize the Likert-scale format. The students are asked to "Strongly agree", "Agree","Neither Agree or Disagree","Disagree", and "Strongly disagree" with selected statements. Kind (2007) developed some of the statements and also selected statements from existing questionnaires. These included

items from the Relevance of Science Education questionnaire, the 2003 Programme for International Student Assessment (PISA) questionnaire, and items from the attitude to science for 5-11 years olds developed by Pell and Jarvis (Kind et. al, 2007). The Kind survey is focused around seven selected components of attitude, learning science in school, self-concept in science, practical work in science, science outside of school, future participation in science, importance of science, general attitude toward school, and combined interest in science (Kind et. al, 2007). For all the attitudes to science measures, the internal validity was calculated using Cronbach's reliability and was found to be above the threshold of 0.7 (Kind et. al, 2007). High correlation between these seven science measures were also noted supporting the use of multiple science measures on one questionnaire (Kind et. al, 2007). High correlation and reliability of the Kind attitude survey make it a suitable attitude survey for this study.

Chapter 3

Earth Space II is a field course learning environment for high school students. The purpose of my study is to determine if Earth Space II increases students' knowledge of the specific educational objectives and has a positive impact on students' attitude toward science.

Variables

The independent variable is the presentation of the material in the format of a field course, Earth Space II. The dependent variables are the students' knowledge of the stated educational objectives and the students' attitude toward science. Student knowledge of the stated objectives will be assessed based upon the difference between pretest and posttest of that knowledge, written responses to questions in student journals and comments made in student workbooks. Impact on students' attitude towards science will be assessed using the difference between pre-survey and post-survey of student attitude toward science.

School

West Noble High School is a rural school located in Ligonier, Indiana. The total number of students at the high school in the 2007-2008 school year was 730. Indiana Department of Education (2009) states that 49% of the student body is on free or reduced lunch. Ethnicity at the school according to the Indiana Department of Education (2009) is 64% White, 34% Hispanic, and 2% multiracial.

West Noble High School has failed to reach No Child Left Behind Annual Yearly Progress (AYP) for the last four years and has been placed on Academic Watch by the Indiana Department of Education (2009). The groups failing to make AYP in both English and math at West Noble High School were Hispanic, Free Lunch and Limited English (IDE, 2009).

In the 2007-2008 school year West Noble High school awarded 59% of their students Core 40 Diplomas and 14% Honors Diplomas, which is below the state average in both diploma type (IDE, 2009).

Instructor

The field course was conducted over a nine day period from June 19th to June 28th 2009 with a total of 15 students from West Noble High School in Ligonier, Indiana. I was the only Indiana certified teacher that presented Earth Space II course material to the students. Mr. Richard Whiteman of Red Metal Minerals and Mr. Ryan Beer or Elkhart County Stone and Gravel assisted in instruction of the students during the students' visit to their respective businesses.

I taught Earth Space II one year prior to the summer of 2009 and also taught a predecessor to Earth Space II, Keweenaw Summer Field Camp, in conjunction Kenton High School for two summers prior to 2008. This has given me a total of three years of teaching a field-based course prior to teaching the 2009 Earth Space II course.

Students

Seventeen high school students elected to take Earth Space II The students that participated in Earth Space II completed a prior course in either Earth Space I or Physics, both of which I teach at the High School. Earth & Space I is classified by the state of Indiana Department of Education to be a Core 40 science class. These means students can take this class to satisfy the science requirements for a Core 40 Indiana High School diploma.

The future offering of Earth Space II was presented to the Earth Space I classes during second semester of 2009. Interested students were then given the opportunity to put their name on a sign-up sheet. Students that placed their names on the sign-up sheet were then given an invitation asking them to speak with other students who participated in Earth Space II the previous year. Students that were still interested in going on the trip after speaking with one or more of the students that had gone the previous year were then given directions on how to officially sign up for Earth Space II in the high school guidance office.

Of the 15 students that participated in Earth Space II for summer 2009, 86% passed both the math and English portions of the Indiana Statewide Testing of Education Progress exam during their sophomore year of high school, 73% received a free or reduced lunch, and 26% were Hispanic. Two of students (13%) were considered special needs and had an Independent Education Plan. Table 1 compares the demographics of 2009 Earth Space II students with 2009 West Noble High School students' demographics and shows that the students enrolled in Earth Space II were on average of lower

Table 1. Comparison of the 2009 Earth Space II course students and the 2009 West Noble High School student body selected demographics

Selected Demographic Indicators	Earth Space II	West Noble High School
Free Reduced or Reduced Lunch	73%	49%
Hispanic	26%	34%
Independent Education Plan	13%	10%
English New Language	13%	5%
ISTEP Pass	86%	59%

economic status, but more educationally prepared than the general student body of West Noble High School.

Daily Schedule and Course Location

The Earth Space II course was conducted at various locations from northeast Indiana to the Keweenaw Peninsula of Michigan. Field course locations were selected based upon geological and instructional interest. Common instructional locations consisted of Michigan state parks and United States national parks and monuments.

A typical day consisted of a morning lecture that gave students information about the day's activities and posed a daily theme/question. Following the morning

information meeting the students would travel to the field locations. A map showing the route of the trip and daily stops is included in Appendix B.

The course began with two days of multiple short stops as we traveled north to and the Porcupine Mountains State park in Keweenaw peninsula. The days spent traveling to the Keweenaw peninsula were used to expose the students to the field environment and introduce them to the dynamics of Earth's surface and the internal and external processes that influence it. The last two days of the trip returned to the driving and short stop format and was more focused on introducing students to the reclamation process and the history of iron mining in the Marquette iron range.

The middle five days of the course was devoted to the mining process. During these days students were housed in the dormitories at Michigan Technological University, and were transported to the Caledonia mine and the White Pine Refinery. Students participated in field activities designed to introduce them to the mining process. Activities include mineral identification, prospecting (exploration) basics, mineral extraction, and refining.

During each day of the trip students were asked to record information and answer questions in a daily workbook. The questions in the daily workbook were designed to get students to make observations and to record useful information that would be used to formulate answers to the questions in the nightly journal.

Several open-ended questions concerning how the trip was going or what was their favorite part of the day, were included in the daily workbook to help assess the students' attitudes during the trip. The daily workbook also included a "your thoughts" section, where students were asked to write down their ideas and impressions of events

that happened during the trip. This section of the daily workbook was not graded; however it was reviewed to collect further qualitative data on students' attitudes toward science.

Each evening students were given their nightly journal. Their nightly journal contained the questions that were correlated to the selected educational objectives (Table 4). The students were directed to answer these questions and to add to their answers as the trip progressed. Students were told to use their daily workbook and the observations (evidence) made during the day to formulate scientific complete answers in their nightly journals. Nightly journals were collected every evening to prevent students from working on the journals during the day and give the instructor a chance to review the journals.

On the third, fifth, and seventh day the students participated in an evening discussion. This discussion time was used to qualitatively evaluate the students' attitude toward the trip and science in general. These discussions were also used to give the students a safe environment to express any frustrations they had with their fellow students. Notes were not taken by the instructor during this time to prevent the students from feeling that what they were saying was not in confidence.

Procedures

Informed Consent. Students' Earth Space II applications included informed consent forms (Appendix C) that were completed and returned to the instructor prior to participation in the course instruction. Each student was assigned an identification number once they had returned their application. Once research was completed all

personal information collected for the research was destroyed. Research protocol has been approved by Michigan Technological Institutional Review Board (M0419).

Table 2. Itinerary for Earth Space II Course

Date (2009)	Activity	Location
Friday (6/19/09)	Pretest Mining Introduction	West Noble High School, Elkhart Stone and Gravel
Saturday (6/20/09)	Mining Glaciation and Dune Formation	Muskegon Dunes, Sleeping Bear Dunes, Petoskey
Sunday (6/21/09)	Tectonics: Water Fall Day	Tahquamenon Falls, Horseshoe Falls, Miners Falls, Agate Falls, and Bonanza Falls.
Monday (6/22/09)	Geology of Keweenaw Peninsula	Porcupine Mountain, South Range, Bumbletown, Cliff Mine, Eagle Harbor, Bluffton Overlook and Copper Harbor
Tuesday (6/23/09)	Mining: Exploration	Caledonia Mine
Wednesday (6/24/09)	Mining: Extraction and Refining	Caledonia Mine, White Pine Refinery
Thursday (6/25/09)	Mining: Exploration and Geology of Keweenaw Peninsula	Seaman Mineral Museum, Quincy Mine & Hoist National Park
Friday (6/26/09)	Mining: Reclamation Tectonics	Champion Mine, National Mine, Michigan Iron Industry Museum
Saturday (6/27/09)	Posttest	Rest-Area (Lunch)

Itinerary. Earth Space II course itinerary (Table 2) was completed as students traveled from northern Indiana to northern Michigan and back.

Students travel time was split between instruction, travel, and non-class time. During some of the travel time students were asked to watch videos that introduced concepts related to the course. The travel time utilized for viewing education videos was included in instruction time. Non-class time included activities such as eating, sleeping and time in the evening to enjoy various camping activities. Table 3 shows the division of time based upon activity.

Testing. The same geoscience concept test, essay test, and attitude survey were given at the beginning and end of the course. Pretests and pre-survey were administered on the first day of class and were stored at the school until the completing of the course (Table 2). The posttests and post-survey were administered north of Grand Rapids, Michigan at a rest area during lunch on the last day of the trip (Table 2). Both sets of tests and surveys were graded at the same time upon the conclusion of the trip.

Table 3. Division of time by activity

Activity	Hours.
Instruction	90 hours
Travel	54 hours
Non-Class	72 hours
Total	216 hours

Instruction. Instruction of the Earth Space II content material occurred over nine days (Table 2). The course focused around outdoor activities and provided students opportunity to experience inquiry. Specific content provided students with opportunities to learn about mining (exploration, extraction, refining, and reclamation) mineral and rock identification, glaciations, rock cycle, tectonics, running water and the water cycle. Each day students were given a brief introduction to the day's activities at breakfast. On days that involved multiple stops students were instructed to make observations as they explored various sites.

The novelty level for students is very high when they are first introduced to a new field environment and this can hinder learning until they are given a chance to explore (Orion & Hofstein 1991, Orion 1993). This initial novelty was utilized to get students to explore the selected sites. After the students were given time to explore, make observations, and fill out information in their daily workbook they were encouraged to ask questions about what they had observed. A Socratic method of teaching was utilized where students' questions were answered with questions and students were continually asked to apply their new knowledge to existing knowledge to form a complete answer for one or more of the questions in their nightly journal (Table 4).

Instructional days five and six were at the Caledonia mine and were more structured than travel days with student participating in preplanned activities. For example, to introduce students to prospecting students participated in a mineral identification laboratory on the waste rock piles.

Selected Indiana State Standards were used to focus the content of this course and to measure the effectiveness of the course instruction. Each day of the trip was focused

around nightly journal question(s), each of which corresponding to selected Indiana state standard (Table 4). The nightly journal questions were also utilized as the essay pretest and posttest questions.

Table 4. Indiana state standards and corresponding nightly journal questions (Essay test item #)

Indiana State Standard	Nightly Journal Questions	Day(s) Addressed
ES 1. 19 **Identify** and **discuss** the effects of gravity on the waters of Earth. Include both the flow of streams and the movement of tides.	• **Explain** how are Gravity and waterfalls related? (Item #1) • What would happen (**infer**) to streams if sea-levels would rise? (Item #2) • Are there tides in the Great Lakes? (Item #3)	June 20th and 21st
ES 1.20 **Describe** the relationship among groundwater, surface water and glacial systems.	• **Describe** what happened to the surface levels of the Great Lakes as the glaciers receded? (Item #4) • **Explain** why the Great Lakes Compact, which regulates diverting large amounts of water from the Great Lakes, also regulates the use of groundwater? Why? (Item #5) • **Describe** what impact groundwater had on the Keweenaw Peninsula? In particular the deposition of copper. (Item #6)	June 21st, 24th,25th, 26th,

Table 4 (continued). Indiana state standards and corresponding nightly journal questions (Essay test item #)

Indiana State Standard	Nightly Journal Questions	Day(s) Addressed
ES.1.22 **Compare** the properties of rocks and minerals and their uses.	• You are given an unknown mineral sample. **Describe** the process that you would use to identify the mineral. (Item #7) • **Explain** the mining process in terms of exploration, extraction, processing, and reclamation. (Item # 8) • Glacial deposits found in quarries are mined for what material? (Item #9) • Hydrothermal deposits are primarily mined for what materials? **Explain** why? (Item #10)	June 19th, 24th,25th,26th and 27th
ES.1.25 **Investigate** and **discuss** the origin of various landforms, such as mountains and rivers, and how they affect and are affected by human activities.	• The Tahquamenon Upper Falls were used as a logging run. The loggers removed smaller waterfalls up-stream from the Upper Falls. **Infer** what impact this human activity had on the Upper Falls? (Item #11) The viewing platform at Lake of the Clouds in Porcupine Mountains gives us a great example of a _________ formed by what geological process? (Item #12)	June 20th, 21st and 22nd

Table 4 (continued). Indiana state standards and corresponding nightly journal questions (Essay test item #)

Indiana State Standard	Nightly Journal Questions	Day(s) Addressed
	• List the three factors that are needed to form dunes. **Explain** how the three are related. (Item #13) • **Explain** how Sleeping Bear Dunes were formed and how this makes them different from the Warren Dunes. (Item #14) • Finger lakes were formed by __________ and have _______ on three sides. (Item #15)	
ES.1. 27. **Illustrate** the various processes that are involved in the rock cycle and **discuss how** the total amount of material stays the same through formation, weathering, sedimentation, and reformation.	• **Explain** the process of hydrothermal deposition of copper? Where did the atoms for the native minerals originate from? (Item #16) • The sand and gravel removed from Indiana quarries originated in ___________ and was moved to their present location by _____________. (Item #17) • From the Brockway overlook you can see prominent hills to the east. These are conglomerate ridges, similar to what you are standing on when you are	June 19th, 23rd, 24th, and 25th

Table 4 (continued). Indiana state standards and corresponding nightly journal questions (Essay test item #)

Indiana State Standard	Nightly Journal Questions	Day(s) Addressed
	• at the overlook. **Explain** what geological process would have formed the valley that separates the two ridges? Make sure you **explain** why the ridges are still present. (Item #18)	
ES.1.23 **Explain** motions, transformations, and locations of materials in Earth's lithosphere and interior. For example, **describe** the movement of the plates that make up Earth's crust and the resulting formation of earthquakes, volcanoes, trenches, and mountains.	• The formation of the Keweenaw Peninsula is part of a giant _________ that goes under Lake Superior. This _______ was caused by a _______ plate boundary. (Item #19) • Motion of tectonic plates causes change in Earth surface. **Explain** what effect tectonic plate motion had on the landscape of the UP, in particular waterfalls?(Item #20) • **Explain** the relationship between tectonic activity and copper deposition in the UP?(Item #21)	June 20th,21st,24th and 25th

Assessment. Measurement of the impact of Earth Space II on student knowledge and attitude was conducted using both quantitative and qualitative data. Quantitative data consisted of two separate pretests and posttests on knowledge and a pre-survey and post-survey of attitude.

Qualitative Data was collected utilizing students' daily workbook and nightly journals. A teacher's daily journal was also kept.

Table 5. Data Sources and Type

	Variable	Type of Data	Collection
Daily Workbook	Knowledge & Attitude	Qualitative	Formative (Daily) and Summative (End of Course)
Nightly Journal	Knowledge	Qualitative	Formative (Daily)
Teacher Journal	Knowledge & Attitude	Qualitative	Formative (Daily)
Concept Test	Knowledge	Quantitative	Summative (Pre-instruction & Post-instruction)
Essay Test	Knowledge	Quantitative	Summative (Pre-instruction & Post-instruction)
Attitude Survey	Attitude	Quantitative	Summative (Pre-instruction & Post-instruction)

Table 6. Bloom's Taxonomy Table of Selected Indiana State Standard and Assessment Items

Knowledge Dimensions	Cognitive Process Dimensions*						
	Remember	Understand	Apply	Analyze	Evaluate	Create	Total%
Factual	**(ES.1.19, Item #2) (ES.1.20, Item # 13) (ES.1.23, Item # 15)	(ES.1.27, Items # 11,12,13,14)					40%
Conceptual		(ES.1.19, Item #1) (ES.1.20, Item #1,3) (ES.1.22, Items #6,7) (ES.1.23 Item #6)		(ES.1.25, Items #8,9,10)			50%
Procedural		(ES.1.22, Items #4,5)					10%
Metacognitive							0%
Total Percent	30%	60%	0%	10%	0%	0%	100%

*Airasian & Miranda, 2002
**Ordered pair Key (Indiana State Standard, Item # on concept test.)

To assist in the alignment of assessment types with the selected standards, the Indiana State standards were placed on a revised Bloom's Taxonomy table (Table 6).

Based on the taxonomic classification of the standards, the majority of the selected state standards (60%) were classified as understand in the cognitive process dimension and the conceptual in the knowledge dimension (50%). Based on this analysis open-ended and free response questions were utilized to assess the selected standards in the students' essay test. The essay test uses the same questions as the nightly journal questions. Verbiage used in the essay test questions and the nightly journal questions was selected to align with the revised Bloom's Taxonomy (Airasian & Miranda, 2002).

The students' essay pretest and posttest were graded by three separate graders using a pre-determined scoring tables (Appendix C). The final points awarded for each essay test question was determined by averaging the three separate scores grades into one. Reliability of my data collection was estimated with correlation. Each variable was measured by at least three data collection sources. The multiple data points allow for a correlation measurement between all the measurements.

Knowledge Assessment

Knowledge was assessed with utilizing pretest and posttest that measured both facts and concepts. The taxonomic classification of the standards resulted in the utilization of two separate tests to measure knowledge. The first test utilized to measure knowledge was a multiple choice concept test. Items from the Geoscience Concept Inventory exam (GCI) developed by Libarkin and Anderson (2004) served as the basis for the concept test. The item stems from the GCI (Item #) were aligned with the course

objectives (Table 6) and modified to match the course content. Some modifications that were made include item #2 which was modified from, what causes most of the waves in the oceans (Libarkin & Anderson 2004), to what causes most of the waves in the Great Lakes. The largest modification came on item #5, which was modified to discuss copper mining in the Keweenaw copper range instead of aluminum mining. This modification resulted in having to change the answer. Originally the correct answer would have been pieces of pure aluminum, which are too small to see even with a microscope (Libarkin & Anderson 2004) to pieces of pure copper, large enough to see with the naked eye.

The second test which was utilized to measure knowledge was in essay format. This test utilized open-ended items that were identical to the student's nightly journal questions. (Table 4) These tests were graded using predetermined scoring tables (Appendix D) by three separate graders.

A pretest for both the concept multiple choice test and the essay test were given on the first day of class at West Noble high school. The posttest for both the concept multiple choice test and essay test were given on the final day of class in a rest area north of Grand Rapids Michigan.

Attitude Assessment

A survey was used to measure the students' change in attitude toward science (Appendix A). The survey was based on the work by Kind (2007). The pre-survey was given the first day of the course, prior to beginning any course instruction. The pre-survey was administered in a classroom at West Noble High School. The post-survey was given in the field on the last day of the course as we traveled back to Indiana. As per

Kind, the survey utilized a Likert scale with five levels of agreement. The points values assigned to the survey were, Strongly agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly Disagree (1). Analysis of both the pre-survey and post-survey was conducted after the course was completed.

Open response areas and questions asking about how the trip was going and what was your favorite part of the day were utilized in the daily workbook to provide qualitative data on students' attitudes during the course.

Continuous Assessment

Student workbooks and journals were collected every evening and reviewed by the instructor when time permitted. An instructor's journal was kept to provide triangulation of data sources. Entries in the teacher's journal focused around self-evaluation of the presented daily tasks, verbal formative assessments of knowledge and attitude asked during the day, and overall impression of students' daily workbook and nightly journal.

Data Analysis

Average item gains in knowledge were measured utilizing the difference in percentage of the individual items on the pre-assessments and the post-assessments. The formula utilized for average gain was:

$$\text{Average Item Gain} = \overline{X}_{\text{class posttest}} - \overline{X}_{\text{class pretest}}$$

Example calculation of data from Item #1 on essay exam (Table 10)

$$46\% = \overline{63}\% - \overline{17}\%$$

The effectiveness of instruction on meeting the selected educational objectives for the group as a whole was measured using effect size (Bracey, 2000). The Earth Space II pretests and pre-surveys were considered the control group and the group's posttests and post-surveys were considered the experimental group. The equation utilized for effect size was:

$$\text{Effect Size} = \frac{\overline{X}_{\text{class posttest}} - \overline{X}_{\text{class pretest}}}{\text{SD}_{\text{class pretest}}}$$

Example calculation of data from survey statement #1 (Table 7)

$$0.52 = \frac{4.60 - 4.13}{0.89}$$

Since effect size is a measure in terms of standard deviation an effect size of +1.0 would represent the equivalent of one standard deviation of movement on a normal bell shaped curve (Bracey, 2000). An effect size interval of importance must be established prior to interpreting effect size. Thompson (2002) recommends reporting and interpreting intervals for effect size in context of prior related research. The effect size intervals for this research are an effect size greater than 0.50 would be considered of great importance, 0.30-0.50 would be moderate importance, 0.10-0.30 would be of small importance and anything smaller than 0.10 would be considered a result of a chance occurrence (Teubert, 2006) and be considered of no importance.

Since no pre-instructional data was collected on students' nightly journal questions these questions could not be used to calculate effect size and gains. The nightly journal questions were utilized for qualitative confirmation of validity of the essay and concept tests effectiveness on measuring student's knowledge gains. For example, students that completed the questions in the nightly journal should have had a positive net gain in knowledge, which would be seen as a positive average gain on the essay and concept tests questions.

Chapter 4

Earth Space II students were asked to participate in pre-survey and post-survey on attitude toward science and two separate knowledge based pretests and two separate posttests of selected educational objectives. Data analysis was done first on the results of the pre-knowledge test and post-knowledge test. A second analysis was done on the pre-survey and post-survey results.

Knowledge Assessment

Student knowledge was assessed using two separate tests that each measured the selected educational objectives. (Appendix A). The first test was the Geoscience Concept Inventory exam, a 15 item multiple-choice format test. The second test consisted of 21 essay items. Students completed both the Geoscience Concept Inventory exam and essay exam assessments as pretests prior to beginning course instruction. Both assessments were administered again at a rest area north of Grand Rapids, Michigan on the return trip. The Geoscience Concept Inventory pretest and posttest utilized the same assessment items to allow for reliability of data. The utilization of the same items one the pretest and posttest was also done for the essay exam. The raw data used to construct the tables 7 through 10 can be found in the Appendix E.

Geoscience Concept Inventory exam. Each student was given a 15 item multiple-choice concept test that utilized item stems from the Geoscience Concept Inventory exam developed by Libarkin and Anderson (2004).

Libarkin (2006) states that construct validity of the Geoscience Concept Inventory was established by utilizing thematic content analysis of open ended questionnaires (n = 1000) and interview data set (n = 75). Libarkin additional states (2006) that content validity of the Geoscience Concept Inventory was established by review of the questions by 3-10 geologist/science educators and review of the revised items by 10 to 21 faculty for content and correctness of response. Libarkin (2006) also concluded that item separation reliability on the Geoscience Concept Inventory was confirmed utilizing Rasch scale stability analysis (scale = 0.99).

Pretest and posttest results for the Geoscience Concept Inventory are shown in Table 7. A small increase in the overall mean was noted on the Geoscience Concept Inventory along with a slight decrease in the Standard Deviation. The raw data used to construct Table 7 is located in Appendix E.

Geoscience Concept Inventory exam effect size. The aggregate effect size for the Geoscience Concept Inventory exam shown in Table 8 is 0.18.

Each selected Indiana state standards was assessed with at least two items on the Geoscience Concept Inventory exam (Table 6). Table 9 shows the calculated mean effect size for each Indiana state standard and the corresponding effect size interval.

Table 7. Geoscience Concept Inventory pretest and posttest: Individual Item percent gain and effect size***

		Class Mean							
Item	N	#Correct	Pretest	SD	#Correct	Postest	SD	%Gain	ES**
1	15	5	33%	0.47	5	33%	0.47	0%	0.00
2	15	6	40%	0.49	11	67%	0.44	33%	0.68
3	15	1	7%	0.25	2	13%	0.33	7%	0.27
4	15	2	13%	0.34	3	20%	0.40	7%	0.20
5	15	12	80%	0.40	15	100%	0.00	20%	0.50
6	15	4	27%	0.44	4	27%	0.44	0%	0.00
7	15	3	20%	0.40	0	0%	0.00	-20%	-0.50
8	15	6	40%	0.49	6	40%	0.49	0%	0.00
9	15	5	33%	0.47	7	53%	0.50	20%	0.42
10	15	4	27%	0.44	4	27%	0.44	0%	0.00
11	15	3	20%	0.40	1	7%	0.25	-13%	-0.33
12	15	3	20%	0.40	2	13%	0.34	-7%	-0.17
13	15	12	80%	0.40	10	67%	0.47	13%	-0.33
14	15	8	53%	0.50	10	67%	0.47	13%	0.27
15	15	0	0%	0.00	7	40%	0.49	40%	0.82*
Mean		4.9	31.1%	0.39	5.7	38.7%	0.37	7.1%	

* Calculated using posttest standard deviation.
**Effect Size
***Raw data is located in Appendix E

Table 8. Geoscience Concept Inventory pretest and posttest: Composite scores

Pretest			Posttest			
N	Mean	SD	N	Mean	SD	ES
15	31.1%	0.39	15	38.7%	0.37	0.18

Table 9. Geoscience Concept Inventory pretest and posttest: Mean effect size for selected Indiana state standards

Indiana state standard	Item #	Mean ES*	ES* Interval
ES.1.19	1, 2	0.34	moderate
ES.1.20	1, 3	0.13	small
ES.1.22	4, 5, 6, 7	0.05	no importance
ES.1.23	6, 15	0.41	moderate
ES.1.25	8, 9, 10	0.14	small
ES.1.27	11, 12, 13, 14	-0.05	no importance

*Effect size

Essay exam. Each student was also given a 21 item essay exam that consisted of open-ended and free-response items. The total points possible on the essay exam were 64 points, with point values varying between questions. The scoring tables used to grade the essay exam are located in Appendix (D).

Content validity of the essay exam items were accomplished through alignment of the items with the Indiana State Standards (Table 4). Individual item percent gain from the pretest to the posttest are shown in Table 10. An increase of 51% in the mean value was seen between the pretest and posttest.

A positive average gain was observed for each item on the essay test from the pretest and posttest. The average percent gain observed from the pretest to the posttest was 51%.

Essay exam Effect Size. The composite effect size for the essay exam shown in Table 11 is 17.0. Despite the increase in effect size the students' posttest mean is still only 54%. Essentially the same items that were given to students for writing prompts in their nightly journals were utilized as the essay exam items. The nightly journal items and the corresponding essay exam item were aligned to selected Indiana state standards (Table 4). Table 12 shows a composite effect size for each Indiana state standard and the corresponding effect size interval.

Table 10. Essay test pretest and posttest: Individual item percent gain*

		Pretest	Posttest	
Item	N	X (%)	X (%)	% Gain
1	15	17%	63%	46%
2	15	7%	39%	32%
3	15	13%	88%	75%
4	15	2%	46%	44%
5	15	0%	30%	30%
6	15	2%	28%	26%
7	15	0%	52%	52%
8	15	0%	52%	52%
9	15	0%	46%	46%
10	15	3%	47%	44%
11	15	3%	36%	33%
12	15	0%	73%	73%
13	15	7%	73%	66%
14	15	0%	51%	51%
15	15	3%	83%	80%
16	15	0%	54%	54%
17	15	4%	76%	65%
18	15	2%	41%	36%
19	15	0%	60%	60%
20	15	0%	56%	56%
21	15	0%	47%	47%
Mean		3%	54%	51%

* Individual item values, along with the raw data is located in Appendix D & E.

Table 11. Essay exam pretest and posttest: Composite Scores

Pretest			Posttest			
N	Mean	SD	N	Mean	SD	ES
15	3%	3%	15	54%	11%	17.0

Table 12. Essay exam pretest and posttest: Mean effect size for selected Indiana state standards

Indiana state standard	Item #	Mean ES*	ES* Interval
ES.1.19	1, 2, 3	12.29	great
ES.1.20	4, 5, 6	35.34	great
ES.1.22	7, 8, 9, 10	37.36	great
ES.1.23	19, 20, 21	9.52	great
ES.1.25	11, 12, 13, 14, 15	23.52	great
ES.1.27	16, 17, 18	0.42	moderate

*Effect size

Science Attitude Survey

Students were given an attitude survey (Kind et al., 2007) to measure their change in attitude toward science (Appendix A) as a result of Earth Space II. The pre-survey was identical to the post-survey. The survey utilized a Likert scale with five levels of agreement. The points values assigned to the survey were, Strongly agree (5 pts), Agree (4 pts), Undecided (3 pts), Disagree (2 pts), and Strongly Disagree (1 pt). Responses were reverse coded for negatively phrased items (Kind et al., 2007) prior to analysis of data. Negative items that were reverse coded are marked in each table.

The attitude survey can be divided into eight components of attitude. The first seven components were part of the original survey (Kind et al., 2007); the eighth component was added for this research:

1. Learning science in school
2. Self-concept in science
3. Laboratory work in science
4. Science outside of school
5. Future participation in science
6. Importance of science
7. General attitude towards school
8. General attitude towards mining and course activities

Validity of the survey was established by Kind (2002) utilizing principle components analysis. Kind (2002) states that the component analysis confirmed convergent and divergent validity at item level. In addition a Cronbach analysis of the

attitude survey showed high internal reliability (Cronbach's $\alpha > 0.7$) (Kind et al., 2002). Although the eighth component was added for this research, the wordings of the items were based off Kind's (2002) original items. For example item #4 of the mining and inquiry component, the benefits of mining are greater than the harmful effects, was modified from Kind's original item, the benefits of science are greater than the harmful effects (Kind et al., 2002).

Results of the survey are presented based upon the above eight components of attitude measured by the survey. The results of the pre-survey and post-survey for each component of attitude will be compared in the following tables. Student responses that were unmarked or double marked were not included in the population for that survey item. The unmarked or double marked responses were also not included in the calculations of the mean or standard deviation. Double marked or unmarked responses accounted for 1% of the responses on the pre-survey and 2% on the post-survey. Raw data used to create the subsequent tables is located in Appendix E.

Learning science in school component. Table 13 compares students' pre-attitude survey and post-attitude survey results for the learning science in school attitude component. Each item for the learning science in school attitude component saw an increase between the pre-survey and post-survey except for doing more science in school. Table 13 shows an increase in the mean Likert score of 3.96 on the pre-attitude survey value to a post-attitude survey mean Likert score of 4.15. Composite effect size for the learning science in school component is 0.26.

Table 13. Science attitude pre-survey and post-survey: Learning science in school component ***

	Pre-Survey			Post-Survey			
Survey Statement	N*	Mean	SD	N*	Mean	SD	ES
1. We learn interesting things in science lessons.	15	4.13	0.89	15	4.60	1.21	0.52
2. I look forward to my science lessons.	15	4.07	0.90	15	4.13	0.80	0.07
3. Science lessons are exciting.	15	4.00	0.81	15	4.13	0.80	0.16
4. I would like to do more science at school.	15	4.07	0.82	14	4.00	0.99	-0.08
5. I like science better than most other subjects at school.	14	3.33	0.53	15	3.67	0.56	0.63
6. It is exciting to learn about new things happening in science.	15	4.00	0.71	15	4.33	1.02	0.47
7. Science is boring.**	15	4.13	1.12	15	4.20	1.24	0.06
Mean		3.96	0.83		4.15	0.95	0.26

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Negative statements were reverse coded for data analysis.
***Raw data is located in Appendix E.

Laboratory work component. Table 14 compares students' pre-survey and post-survey results for the laboratory work attitude component. The most notable increase in student mean scores occurred on the item six, "We learn science better when we do lab work" and one, "Lab work in science is exciting". The mean values for items three, four, and five all decreased from the pre-survey to the post-survey. Table 14 shows means scores for the pre-survey and post-survey were similar, 3.73 and 3.84 respectively. The composite effect size for the laboratory work attitude component is 0.16.

Science outside of school component. Table 15 compares students' pre-survey and post-survey results for the science outside of school component. Table 15 shows means scores for the pre-survey and post-survey were 3.36 and 3.60 respectively. The greatest increase was noted on items three and five. Item four had a decrease in the mean value. Composite effect size for the outside of school component is 0.57.

Table 14. Science attitude pre-survey and post-survey: Laboratory work component***

	Pre-Survey			Post-Survey			
Survey Statement	N*	Mean	SD	N*	Mean	SD	ES
1. Lab work in science is exciting.	15	3.73	0.66	14	4.07	1.10	0.50
2. I like science lab work because you don't know what will happen.	15	3.73	0.66	14	3.73	0.85	0.00
3. Lab work in science is good because I can work with my friends.	14	3.13	0.82	15	3.07	0.47	-0.08
4. I like lab work in science because I can decide what to do myself.	15	3.93	0.79	15	3.67	0.88	-0.34
5. I would like more lab work in my science lessons.	15	3.93	0.79	15	3.87	0.88	-0.08
6. We learn science better when we do lab work.	14	3.13	0.77	15	4.00	0.89	1.12
7. I look forward to doing science lab.	15	4.20	1.24	15	4.13	1.12	-0.05
8. Lab work in science is boring.**	15	4.00	0.89	15	4.20	0.82	0.23
Mean		3.73	0.83		3.84	0.87	0.16

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Negative statements were reverse coded for data analysis.
***Raw data is located in Appendix E

Table 15. Science attitude pre-survey and post-survey: Science outside of school component**

Survey Statement	Pre-Survey			Post-Survey			
	N*	Mean	SD	N*	Mean	SD	ES
1. I would like to join a science club.	15	3.20	0.37	14	3.20	0.49	0.00
2. I like watching science programs on TV.	15	3.47	0.45	15	3.47	0.42	0.00
3. I like to visit science museums.	14	3.33	0.53	15	4.20	0.89	1.64
4. I would like to do more science activities outside school.	15	3.87	0.97	14	3.73	1.06	-0.14
5. I like reading science magazines and books.	15	2.93	0.35	15	3.40	0.68	1.33
Mean		3.36	0.54		3.60	0.71	0.57

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Raw data is located in Appendix E

Importance of science component. Table 16 compares students' pre-survey and post-survey results for the importance of science component. An increase in the pre-survey mean and post-value mean value of each item was observed except for "Science and technology is important to society". Table 16 shows means scores for the pre-survey and post-survey were 3.72 and 3.96 respectively. Composite effect size for the importance of science component is 0.25.

Table 16. Science attitude pre-survey and post-survey: Importance of science component**

	Pre-Survey			Post-Survey			
Survey Statement	N*	Mean	SD	N*	Mean	SD	ES
1. Science and technology is important for society.	14	4.33	1.27	14	4.13	1.12	-0.16
2. Science and technology makes our lives easier and more comfortable.	15	4.13	1.12	15	4.47	1.10	0.30
3. The benefits of science are greater than the harmful effects.	14	3.07	0.86	13	3.27	0.71	0.23
4. Science and technology are helping the poor.	15	3.27	0.75	15	3.53	0.72	0.36
5. There are many exciting things happening in science and technology.	14	3.80	1.19	15	4.40	1.09	0.50
Mean		3.72	1.04		3.96	0.94	0.25

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Raw data is located in Appendix E.

Self-concept in science component. Table 17 compares students' pre-survey and post-survey results for the self-concept in science attitude component. Table 17 shows mean scores for the pre-survey and post-survey were 3.19 and 3.36. Three of the six items were negative, and were reverse coded for data analysis. The mean values for items three and seven decreased from the pre-survey to the post-survey. Composite effect size for the self-concept in science component is 0.34.

Table 17. Science attitude pre-survey and post-survey: Self concept in science component***

	Pre-Survey			Post-Survey			
Survey Statement	N	Mean	SD	N*	Mean	SD	ES
1. I find science difficult.**	15	2.93	0.52	15	2.93	0.74	0.00
2. I am just not good at science.**	15	2.47	0.48	15	3.80	1.00	2.76
3. I get good marks in science.	15	3.73	0.98	15	3.67	0.88	-0.07
4. I learn science quickly.	15	3.13	0.61	15	3.47	0.60	0.54
5. Science is one of my best subjects.	15	3.53	0.55	15	3.53	0.55	0.00
6. I feel helpless when doing science.**	15	3.73	0.56	15	3.73	0.98	0.00
7. In my science class, I understand everything.	15	2.80	0.48	14	2.40	0.55	-0.83
Mean		3.19	0.60		3.36	0.76	0.34

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Negative statements were reverse coded for data analysis.
***Raw data is located in Appendix E.

Future participation in science component. Table 18 compares students' pre-survey and post-survey results for future participation in science attitude component. Table 18 shows means scores were 3.13 on the pre-survey and 3.36 on the post-survey. Item one had the only decrease in mean value from the pre-survey to the post-survey. Composite effect size for the future participation component is 0.43.

Table 18. Science attitude pre-survey and post-survey: Future participation in science component**

Survey Statement	Pre-Survey			Post-Survey			
	N*	Mean	SD	N*	Mean	SD	ES
1. I would like to study more science in the future.	15	3.93	0.79	14	3.73	0.85	-0.25
2. I would like to study science at university.	15	3.73	0.76	15	3.80	0.79	0.09
3. I would like to have a job working with science.	15	3.20	0.35	15	3.47	0.52	0.76
4. I would like to become a science teacher.	15	2.53	0.53	14	2.87	0.63	0.63
5. I would like to become a scientist.	13	2.27	0.73	15	2.93	0.53	0.92
Mean		3.13	0.63		3.36	0.66	0.43

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Raw data is located in Appendix E.

General attitude towards school component. Table 19 compares students' pre-survey and post-survey results for the science general attitude toward school component. Mean scores for the pre-survey and post-survey were, 3.61 and 3.77 respectively. Items one and seven are negative statements and were reverse coded for data analysis. Composite effect size for the outside of school component is 0.23.

Table 19. Science attitude pre-survey and post-survey: General attitude towards school component***

	Pre-Survey			Post-Survey			
Survey Statement	N*	Mean	SD	N*	Mean	SD	ES
1. Most of the time I wish I wasn't in school at all.**	15	3.60	0.75	14	3.80	0.78	0.27
2. I get on well with most of my teachers.	15	4.40	1.09	15	4.33	0.98	-0.06
3. I am normally happy when I am in school.	14	3.53	1.06	15	4.13	0.93	0.57
4. I work as hard as I can in school.	15	3.20	0.35	16	3.47	0.46	0.76
5. I really like school.	15	3.47	0.76	14	3.60	0.70	0.17
6. I would recommend this school.	15	3.47	0.76	15	3.93	0.65	0.61
7. I find school boring.**	15	3.73	0.72	14	3.47	0.81	-0.37
8. I feel that I belong in this school.	15	3.47	0.60	15	3.40	0.42	-0.11
Mean		3.61	0.76		3.77	0.72	0.23

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
**Negative statements were reverse coded for data analysis.
***Raw data is located in Appendix E.

Mining and course activities attitude items. Table 20 compares students' pre-survey and post survey results for attitude items related to mining and course activities. Table 20 shows means scores for the pre-survey and post-survey were, 3.39 and 4.03 respectively. All items showed an increase in value from the pre-survey to the post-survey. Composite effect size for the outside of school component is 0.90.

Table 20. Science attitude pre-survey and post-survey: Mining and inquiry component**

	Pre-Survey			Post-Survey			
Survey Statement	N*	Mean	SD	N	Mean	SD	ES
1. I enjoy collecting rocks and minerals.	14	3.00	0.92	15	4.00	1.00	1.09
2. Mining is important for society.	15	3.60	0.77	15	4.20	1.04	0.78
3. Mining makes our lives easier and more comfortable.	15	3.53	0.74	15	4.00	1.10	0.63
4. The benefits of mining are greater than the harmful effects.	15	2.87	0.53	15	3.67	0.63	1.51
5. I enjoy learning science by asking questions and answering my own questions.	15	3.93	0.71	15	4.27	0.89	0.47
Mean		3.39	0.73		4.03	0.93	0.90

* Unmarked or double marked responses were not included in the population or calculations of means and standard deviation.
** Raw data is located in Appendix E.

Effect size of attitude components. Table 21 shows the mean effect size for each attitude component along with the importance of each value based upon the selected effect size intervals. Attitude components, 1, 2, 3, 6, and 7 were of small importance (0.1-0.3). Attitude components 4 and 5 were of moderate importance (0.3-0.5). Attitude component eight was of great importance (>0.5).

Table 21 Science Attitude Survey: Effect size of attitude components

Attitude Component	Effect Size	Importance
1. Learning science in school	0.23	Small
2. Self-concept in science	0.29	Small
3. Laboratory work in science	0.14	Small
4. Science outside of school	0.45	Moderate
5. Future participation in science	0.36	Moderate
6. Importance of science	0.23	Small
7. General attitude towards school	0.21	Small
8. General attitude towards mining and inquiry	0.87	Great

Chapter 5

The goal of this research was assesses high school students that were exposed to a field course. It was my intent that through careful assessment of the course objectives and curriculum I would be able to provide new data on the impact of a field course on high school students' understanding and attitudes.

Analysis of data on students' understanding of selected state objectives

The first research question, will Earth Space II positively change participants' knowledge of the selected Indiana Science Standards given that it was "optimized for learning" (Huntoon et al., 2007)? This research questions was assessed utilizing the Geoscience Concept Inventory exam and an open-ended essay exam.

Geoscience Concept Inventory exam. The administered Geoscience Concept Inventory exam had a composite effect size of 0.18 between the pretest and posttest. This effect size is considered of small importance on the effect size intervals selected for this research. Although this effect size was positive, the magnitude would indicates that Earth Space II barley meet the educational objectives. Although the composite effect size did show a small effect size on the effect size intervals, it may be useful to look at the effect size of several individual items on the Geoscience Concept Inventory exam to gain additional information about student understanding.

Table 6, which is a modified Bloom's Taxonomy Table (Airasian, 2002) shows that items 11, 12, 13, and 14 (ES.1.27) align with the factual knowledge dimension and understand cognitive process dimension. Three of these four items, Items 11, 12, and 13,

had negative effect sizes (Table 7). This cluster of negative effect sizes would indicate that Earth Space II was not effective for either of these two dimensions.

Table 6, also shows that items 9, 8, 10 (ES.1.25) align with the conceptual knowledge dimension and the analyze cognitive process dimension. Two of these three items had positive effect sizes on the Geoscience Concept Inventory (Table 7). This cluster of positive effect sizes would indicate that Earth Space II had a positive impact on students' understanding of the educational objectives that align with these two dimensions of the revised Bloom's Taxonomy (Airasian, 2007).

The composite effect size for the Geoscience Concept inventory may have shown that the educational objectives were not definitively met by Earth Space II; however individual items on the Geoscience Concept Inventory show that students performed differently based on which knowledge dimension and cognitive process dimension aligned with the assessment items.

An evaluation of the effect size between the Geoscience Concept Inventory pretest and posttest for each selected Indiana state standard is shown in Table 9. Table 9 shows that two of the selected Indiana state standards (ES.1.22 and ES.1.27) had an effect size interval of no importance and would be considered not met objectives. The selected standard ES.1.27 had an effect size interval of -0.05 between the pretest and posttest (Table 9) and aligns with the conceptual knowledge dimension and the analyze cognitive process dimension (Table 6). The remaining four selected Indiana state standards could be considered met since they all had positive effect sizes ranging from small to moderate importance (Table 9). Standard ES.1.23 had a moderate effect size interval (Table 9) and aligned with the knowledge dimensions of factual and conceptual and the cognitive

process dimensions of remember and understand (Table 6). This data further supports the idea that that students performed differently based on which knowledge dimension and cognitive process dimension.

Essay exam. The essay test of student knowledge had a composite effect size of 17.0 (Table 11), which is of great importance on the selected effect size intervals. This large effect size indicates that Earth Space II met the state educational objectives.

The large increase in effect size was supported by a positive average gain on all the essay test items (Table 10). Item #7 showed the largest average percent gain of 52%. This item was related to the process of identifying an unknown mineral sample. Students were given very little verbal directions on how to identify minerals, however they were given a lot of time to use their identification tables to identify samples and construct their own understanding of the mineral identification process.

The lowest average gain of 26% was observed on Item #6. This question was related to the impact of groundwater on the Keweenaw Peninsula. Eight of the fifteen students answered with a similar incorrect answer. Instead of explaining how groundwater deposits copper, they explained how Torch Lake and the surrounding groundwater were contaminated by the dumping of stamp sands from nearby copper mines into the lake. Although students demonstrated an understanding of the connection between groundwater and surface water, this was not the intended concept for this question.

Table 6 indicated that the majority of the selected Indiana state standards (60%) were classified as understand in the cognitive process dimension and conceptual in the

knowledge dimension (30%). Open-ended and free response assessment items were utilized on the essay exam based on this classification. The great importance of the effect size supports my idea that Earth Space II would give students the opportunity to observe and describe their natural world and construct their own knowledge resulting in a positive increase in the students understanding of the selected Indiana state standards.

An evaluation of the effect size between the essay exam pretest and posttest for each selected Indiana state standard is shown in Table 12. Table 12 shows that all the selected Indiana state standards assessed by the essay exam had an effect size interval of great importance. Table 12 indicates that the objective of Earth Space II to have a positive impact on students' knowledge of the selected Indiana state standards was met.

Impact of Earth Space II on students' knowledge of selected Indiana state standards. So what conclusion can be drawn from the data analysis? Did the Earth Space II provide an optimal learning environment for high school students? The results of the Geoscience Concept Inventory Exam and the essay exam assessment together do not definitively confirm that Earth Space II created an increase in students' knowledge of the selected Indiana state standards. The composite effect size for the Geoscience Concept Inventory was of small importance on the selected effect size intervals, yet the effect size for the essay exam was of great importance. Evaluation of the effect size of each selected Indiana state standards on the knowledge assessments (Tables 9 and Table 12) shows that the two selected Indiana standards (ES.1.19 and ES.1.23) on the essay exam with the lowest effect size values (Table 12) had the greatest effect size values on

the Geoscience Concept Inventory exam (Table 9). These results appear to represents a discrepancy in the data.

Upon further analysis this apparent discrepancy makes sense. Earth Space II was intended to develop one or more of the traits of scientific literacy; using scientific knowledge, constructing scientific knowledge, and reflecting on scientific knowledge, as defined by MEGOSE (1995). It was expected that an increase in scientific literacy would result in students gaining a deeper understanding of geoscience concepts. The open-ended essay exam items, which were written based upon the selected Indiana state standards (Table 6), were intended to measure students' scientific literacy. The Geoscience Concept Inventory exam items, which were chosen based upon their alignment with the selected Indiana state standards (Table 6), sought to measure students increase in geoscience concepts. Since the Geoscience Concept Inventory exam was intended to measure the students knowledge of the selected Indiana state standards based upon a change in the knowledge of geoscience concepts and the essay test was measuring the students change in knowledge based on a change in scientific literacy, we can make a conclusion utilizing this observed dichotomy in the data.

Earth Space II did have a positive impact on students' growth in terms of scientific literacy. This growth in scientific literacy was observed in the positive increase in knowledge on the essay exam and the met objective on each selected Indiana state standard. The large growth in scientific literacy did not directly translate to a large in increase in students' understanding of specific geoscience concepts, as observed by the small increase of knowledge on the Geoscience Concept Inventory exam and not met objective of Indiana standard ES.1.27.

Analysis of data on student attitude toward science

The second research questions was will Earth Space II positively change participants' attitude towards science with respect to the 8 components of attitude (Kind et al., 2002)? Data shows that each of the eight attitude components had a positive mean effect size (Table 21). These positive effect sizes would indicate that Earth Space II did met the objective of increasing students' attitude toward science.

Individual components of attitude. The greatest effect size was observed on the attitude towards mining and course activities attitude component. This component was not one of the original attitude components in Kinds (2002) attitude survey and it reliability is unverified. This attitude component was intended to measure any change in students' attitude toward mining and course activities, using modified survey stems from the original Kind (2002) survey. The highest effect size value was noted on item 4, with a value of 1.51. Such a large effect size can be expected since most of the students had little to no exposure to mining prior to this course and the students were given an opportunity through Earth Space II to experience the mining process utilizing hands-on learning.

Although all of Kind's (2002) original seven components of attitude had a positive effect, only two of the components had an effect size value of moderate importance (Table 21). One of the components to have a moderate effect size value was science outside of school (Table 21). The moderate mean effect size for the science outside of school component was not consistent across the individual survey items (Table 13). Two of the items, 1 and 2 had no increase in the mean Likert value from the pre-

survey to the post-survey. Item 4, I would like to do more science activities outside of school, actually had a negative effect size of -0.14. Two of the survey items, had effect size values over one. Item 3, I like to visit science museums, had an effect size of 1.64 (Table 21). The Earth Space II course visited three museums, Seaman Mineral Museum, Quincy Mine and Hoist National Park, and the Michigan Iron Industry Museum. Teacher observations of students at these three museums support this increase in effect size. Students were actively engage at the museums, asking questions of either museum personal or the instructor, and participating in museum activities and displays. Item 4, I would like reading science magazines and books, had an effect size of 1.33. The only written material that students were exposed to during the trip was their daily and nightly journals. This increase indicates that students either missed having a text book or enjoyed the simplistic format of the journals compared to a regular text book. The great effect size values or items 3 and 4 resulted in the moderate effect size value for the science outside of school component.

The other attitude component to be considered of moderate importance was future participation in science. This attitude component had an effect size of 0.36. The individual survey items for this attitude component all had a positive effect size value, except for item 1, I would like to study more science in the future (Table 20) The negative value for this item seems to be supported by the small effect size, 0.09, for item 2, I would like to study science at university (Table 20). Both values for items 1 and 2 would be considered of small importance on the selected intervals, were the remaining three items, 3, 4, and 5, would all be considered of great importance. The three remaining survey items for this attitude component relate to jobs in the science field. The

large effect size on these items would indicate that the students would like to have a job in science; however the low effect size on the first two survey items would indicate that they do not necessarily want to complete the school work needed to get these jobs.

The attitude component, laboratory work in science, had the smallest effect size value of 0.14, which is considered of small importance on the selected effect size intervals. The individual survey items for this component that had negative effect sizes were items 3, 4, 5 and 6 (Table 14). Of these three items, item 4, I like lab work in science because I can decide what to do myself, had the largest negative effect size value of -0.34. This negative value is considered of moderate significance and may indicate that student would enjoy more structure when doing lab activities in Earth Space II. Although item 4 may have indicated some frustration on the part of the students, item 6, we learn science better when we do lab work, had an effect size of great importance, 1.12 (Table 14). These two items taken together would indicate that the students may have been frustrated with the lack of directions at times, however realized that they did learn better when doing lab work.

Corroborating qualitative evidence on students' attitude toward science. A teacher journal was kept during the Earth Space II course and also utilized during the review of students daily and nightly journals. Student attitudes during the daily field activities were observed to be relatively positive. Students did appear slightly frustrated at times the fact that they could not spend additional time a certain stops or get additional time on certain activities. This frustration with the pace of the course appeared to increase as the trip went on. It was also observed that towards the end of the trip students' interest seemed to

wan. This decrease in interest was noted in students' attitudes toward the end of the trip. Several students began complaining about the meals and sleeping conditions. No negative comments were made concerning the course or science in general. Several times during the trip, students made comments about how much the enjoyed the class, and thanked me for taking them on the trip. Most of these positive comments were made while students were doing daily field activates. For example, one student expressed that Agate falls was just amazing and that she loved it.

Review of the students' daily workbooks confirmed observations made by the instructor. The students' daily workbooks included a thoughts section and a question asking, so how is it going, do you think you are getting this stuff? None of the students made negative comments toward science or the course content in answering this question. One student did voice frustration with the physical requirements of the course, however even with this frustration no negative comments were made concerning science or the course. Some of the student did voice some frustration with the pace of the course, an observation also made by the instructor. One student stated, I have learned a lot and it has been fun. I think I'm getting most of it even though there's a lot to take in. Although some frustration no overtly negative comments were observed in the review of the student workbooks. One student did write a thank you letter in her thoughts section expressing her enjoyment of the course; this is something I will never forget in my life and something I will probably never be able to experience again.

Impact of Earth Space II on students' attitude toward science. Earth Space II did have a positive impact on students' attitude toward science. This was observed in a

positive effect size on all eight attitude components (Table 21). While some individual survey items had negative effect sizes, the overall mean Likert value increased from the pre-survey to the post-survey. Instructor observations and student comments did collaborate the positive effect sizes and increase in the mean Likert value observed in the survey data.

General Discussion of Earth Space II impact on students

Earth Space II provided the students with an optimal learning environment, which gave them a chance to use and construct scientific knowledge. A positive increase was seen in both the knowledge assessments and attitude assessment of the students.

A positive increase was noted in students' ability to use what they had observed to increase their knowledge of the selected Indiana state standards. This positive increase was most evident on the students' essay exam. The essay exam format gave students the ability to express their gained knowledge. The increase in the mean between the pretest and posttest was also accompanied by an increase in the student use of evidence. A scientifically literate individual is capable of using scientific knowledge, constructing scientific knowledge, and reflecting on scientific knowledge (MEGOSE, 1995). The increase in the use of evidence and giving priority to evidence shows that Earth Space II had a positive impact on students' scientific literacy.

A negative observation made as a result of asking students to construct their own understanding based on their observations was observed on Item# 6 on the essay exam. A quarter of the students gave an incorrect answer, which was based on the application of the wrong geological concept. I think that so many of the students gave the wrong

concept because they related the word impact in the item to their visit at Torch Lake. While at Torch Lake, the class discussed the impact of the contamination on the lake and surrounding groundwater. Students were expected to construct their own knowledge using observations that they made during the trip and from questions they asked the instructor. Students apparently remembered the discussion of impact at Torch Lake and used this concept for their answers on Item #6. This type of negative observation shows that an instructor must be careful in their selection of vocabulary on assessment items. It also shows that an instructor must understand that students will not always construct the knowledge that instructor expects.

Some minor frustration was noted by students concerning the pace of the course. Several individual items on the attitude survey showed negative effect sizes. These negative items indicate that although Earth Space II does provide an overall positive experience, it does not positively impact all aspects of science. As previously noted that the students may have been frustrated with the lack of directions at times, however realized that they did learn better when doing lab work.

The greatest impact on student attitude may have resulted in just exposing the students to the beauty of nature. A student wrote noted in her daily workbook, I am having a great time I am injoying [sic] the trip and loveing [sic] all the beautiful place's we are seeing the waterfalls are so amazing and the view's [sic] of the lakes we got to see made me have a different view of nature. This student summarized many similar comments expressed by the students that participated in Earth Space II.

Future recommendations for Earth Space II

Earth Space II is an annual summer course offered by West Noble High School. Based upon data collected from this research I plan on suggesting the following modifications.

Recommendations for knowledge assessments. The use of two separate assessments of knowledge provided a view of an interesting contrast of the students' knowledge gains as a result of participating in Earth Space II.

The use of the Geoscience Concept Inventory provided a valid assessment of students' geosciences concepts. My use of the Geoscience Concept Inventory was motivated by the use of the Geoscience Concept Inventory by Elkins (2007). Elkins (2007) was able to compare the mean pretest scores and posttest scores of his students to 29 other introductory geosciences course from across the United States. Prior to comparison to the other geosciences course Elkins (2007) scaled students' raw scores using Rasch analysis. Libarkin (2006) chose four anchoring items for statistical similarity between Geoscience Concept Inventory sub-tests that were scaled using Rasch analysis. Two of the four anchoring items required for Rasch analysis did not align with the selected Indiana state standards for Earth Space II. These items did not align with Earth Space II, because they were historical geology questions, a subject not covered in great detail by the course curriculum. Since the pretest data and posttest data for Earth Space II could not be scaled using Rasch analysis, they were not comparable with other institutions. In the future I would like to be able to modify the Earth Space II assessment to allow for the comparison of the pretest and posttest results to other institutions. The

inclusion of the two historical geology items would require a change in the Earth Space II curriculum. An addition of a historical geology component would be possible, however it would require and additional day of field activities.

The essay exam provided further insight into how the students' used the knowledge they acquired as a result of participating in Earth Space II. Although the essay test provided some insight, the amount of time required to grade the exam was not practical. It took three instructors and average of 10 hours each to grade the fifteen essay exams. The essay test had three items per selected Indiana state standard. In the future I will most likely reduce the number of assessment items on the essay exam. A careful comparison of future essay exams with the original longer exam would be required to make sure that the shorter essay exams remain valid.

The attitude survey used in Earth Space II was developed by Kind (2007). This attitude survey was selected because I chose to use Kind's (2007) definition of attitude. Attitude for this research was defined as the feeling a person has about an object, based on their beliefs about that object. Although I still agree with Kind's (2007) definition of attitude, I feel the survey itself needs some modification. The Likert scale utilized by Kind (2007) included a "neither agree nor disagree" statement. This statement was reworded to "undecided" on the Earth Space II science attitude survey (Appendix A). I feel that this statement provided students an opportunity to avoid having to make a decision about the survey item. In the future I will modify the Likert scale on the attitude survey not to include this statement.

Recommendations for Earth Space II curriculum. Several problems that I observed during the research that relates to the curriculum of Earth Space II were the amount of travel time, non-instructional distraction, and lack of time for formative assessments.

The problem of too much time spent on travel has been an issue every year Earth Space II and its predecessor Keweenaw Summer Field camp has been taught. A total of 54 hours, approximately 25% of the total time was spent on travel (Table 3). This year I tried to address the problem by showing several videos related to the sites the students would visit. The six videos, which were shown at different times during the trip totaled 1.6 hours or a decrease in travel time of 3%. The issue of travel time is inherent in Earth Space II, due to the fact that on average 2000 miles are traveled during the nine day course. In the future I will continue refining the schedule of Earth Space II to reduce the total mileage of the course by preventing multiple trips back and forth between Michigan Technological University and the Caledonia mine. One option is to add an additional day of camping at the Union Bay state campground by Silver City, Michigan. This additional day of camping would eliminate some of the mileage gained from back and forth travel. One additional day of camping was added this year to prevent traveling late at night on day four (6-22-09). This change in schedule reduced the number of evenings spent in the dorms at Michigan Technological University to two nights. It has been noted in years past that both students and instructors, enjoy the break from camping. The dorms provide a base camp, which gives the student a chance to do laundry and get a feeling of normalcy, to an otherwise hectic week. Although small changes in schedule may reduce some travel, the inherent problem is that no matter how much extra travel is eliminated West Noble High School is still 688 miles from Michigan Technological University.

Another problem noted in Earth Space II was the increase non-instructional distractions. Non-instructional distractions are something that are inherent in all field activities. One of the most common distractions, that I have noted, is students developing relationships with other students while on the trip. Two students, for example, started a relationship while on the trip, although the female student did not appear to suffer much from the new relationship, the male student was notably distracted. I noted that this student stopped asking as many questions during field activities and even had to be spoken to at one location because he was too busy staring at his new friend to make any observations. Upon review of his daily journal, the thoughts you had during the trip section of the journal included a reference to a cuddly poodle. The impact of this relationship was noted on this student's Geoscience Concept Inventory exam posttest, which was 20% lower than his pretest. In the future I will seek to limit the amount of non-instructional distractions by addressing them on the first day of class. Students that are taking Earth Space II have had me for other classes at West Noble High school. Since these students tend to be more mature, I feel that if students are told that relationships may form on this trip, however such relationships will not be allowed to interfere with their education would provide enough of an intervention. If this assumption is not true, then other standard classroom management techniques, such as separation of students during class activities could always be applied.

The lack of time to perform formative assessment, proved to be the largest problem. I expected to be able to review the daily and nightly journals each day. This formative assessment only happened three times during the trip. I feel this problem contributed to the students miss understanding of impact on item #6 on the essay test.

Review of the nightly journals after the course was complete showed that many of these students had written down the incorrect answer in their nightly journal. If I would have had time to review these journals during the course, I would have been able to address this misunderstanding. This lack of time for formative assessment can be solved by having another person drive the bus. A person was scheduled to drive the bus this year; however he became sick the first day of Earth Space II and was not able to finish the course, leaving me as the only driver. A reduction in my non-instructional duties would allow for more time to complete formative assessment and be available for answering student questions.

Educational implication and future research

Knowledge assessments. Studies have shown that graduates of Geoscience programs feel that a field course is an important component of becoming a Field Geologist (Plymate et al, 2005). However, field trips and field course are not a common component of science courses (Elkins J. & Elkins N., 2007). For example, Earth Space II is the only field course that is offered to students at West Noble high school or in Noble county as a whole. Only three science field trips are conducted throughout a typical school year at West Noble high school. One of the problems with conducting a field course or even a smaller field trip is the assessment of the student's gains in knowledge. Careful assessment of Earth Space II shows that a positive increase in students' knowledge of the selected educational objectives can be obtained.

Attitude toward science assessment. Kelly (1986) stated that attitude can be viewed as having a more lasting power compared to the knowledge acquired by students in science. If the goal of a science teacher is to inspire their students to become more involved in their world and to be supportive of the sciences in the future, then it is clear that assessment of students' attitude is just as important as assessment of their knowledge. Pell and Jarvis (2001) stated that as science concepts became more in-depth, they also became more abstract, resulting in science attitudes becoming more negative with older students. Earth Space II sought to expose students to a field course experience that would provide them with an authentic scientific experience. Careful assessment of Earth Space II indicates that a field course may provide an optimal learning strategy (Huntoon et al., 2001) which creates an effective means of increasing high school students' attitude toward science.

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Appendix A: Assessment Tools

Earth Space II
Science Attitude Survey
(Kind et al., 2007)

Read the following statements. Once you have read the statements mark if you strongly agree (5), agree (4), neither agree or disagree (3), disagree (2), or strongly disagree (1) with the statement you read.

Statement	Strongly Disagree (1)	Disagree (2)	Neither (3)	Agree (4)	Strongly Agree (5)
We learn interesting things in science lessons.					
I look forward to my science lessons.					
Science lessons are exciting.					
I would like to do more science at school.					
I like Science better than most other subjects at school.					
Lab work in science is exciting.					
I like science lab work because you don't know what will happen.					
Lab work in science is good because I can work with my friends.					
I like lab work in science because I can decide what to do myself.					
I would like more lab work in my science lessons.					
I would like to join a science club.					
I like watching science programs on TV.					
I like to visit science museums.					
I would like to do more science activities outside school.					
I like reading science magazines and books.					
Science and technology is important for society.					
Science and technology makes our lives easier and more comfortable.					
The benefits of science are greater than the harmful effects.					
I really like school.					
I would recommend this school.					
I find school boring.					
I feel that I belong in this school.					
Science is boring.					

Statement	Strongly Disagree (1)	Disagree (2)	Neither (3)	Agree (4)	Strongly Agree (5)
I find science difficult.					
I am just not good at Science.					
I get good marks in Science.					
I learn Science quickly.					
Science is one of my best subjects.					
I feel helpless when doing Science.					
In my Science class, I understand everything.					
We learn science better when we do lab work.					
I look forward to doing science lab.					
Lab work in science is boring.					
It is exciting to learn about new things happening in science.					
I would like to study more science in the future.					
I would like to study science at university.					
I would like to have a job working with science.					
I would like to become a science teacher.					
I would like to become a scientist.					
Science and technology are helping the poor.					
There are many exciting things happening in science and technology.					
Most of the time I wish I wasn't in school at all.					
I get on well with most of my teachers.					
I am normally happy when I am in school.					
I work as hard as I can in school.					
I enjoy collecting rocks and minerals.					
Mining is important for society.					
Mining makes our lives easier and more comfortable.					
The benefits of mining are greater than the harmful effects.					
I enjoy learning science by asking questions and answering my own questions.					

Earth Space II
Geoscience Concept Inventory

GCI v.2.1.1: Text revisions by J.C. Libarkin based on community input and reanalysis of psychometric standards. Figures public domain revisions by S.K. Clark (Libarkin & Anderson 2005)

Please answer the following questions to the best of your ability.

1. What is the connection between clouds and rain?

(A) Clouds are empty, and fill up with water. When the clouds are full, it rains
(B) Clouds are empty, and fill up with water and other things. When the clouds are full, it rains
(C) Clouds are empty, and fill up with water. When the clouds get too heavy, it rains
(D) Clouds are made up of water. When the temperature gets high enough in the cloud, it rains
(E) Clouds are made up of water. When the temperature gets low enough in the cloud it rains

2. What causes most of the waves in the Great Lakes?

(A) Tides
(B) Earthquakes
(C) Wind
(D) Tsunamis

3. Where do you think glaciers can be found today? **Choose all that apply.**

(A) In the mountains
(B) At sea level
(C) At the South pole
(D) Along the equator only
(E) Anywhere except along the equator

4. A student finds a dull black rock in Marquette. She puts a magnet next to it, and the magnet is not attracted to the rock. Which of the following statements best describes the rock?

(A) Iron could be present in the rock because some black rocks contain iron
(B) Iron is definitely present in the rock because black rocks contain iron
(C) No metals are present in the rock because metals are magnetic
(D) Iron is not present in the rock because red rocks contain iron
(E) No metals are present in the rock because shiny rocks contain metal

5. Copper is a metal that is mined. If you were to visit a copper mine in the Keweenaw copper range, what would the copper found in the mine look like?

(A) Pieces of copper mixed with other things, which are large enough to see with the naked eye
(B) Pieces of pure copper, which are large enough to see with the naked eye
(C) Pieces of copper mixed with other things, which are too small to see without a microscope
(D) Pieces of pure copper, which are too small to see without a microscope
(E) Pieces of pure copper, which are too small to see even with a microscope

6. Which of the following statements about the age of rocks found in Northern Michigan is most likely true?

(A) Rocks found in the ocean are about the same age as rocks found in Northern Michigan
(B) Rocks found in Northern Michigan are generally older than rocks found in the ocean
(C) Rocks found in the ocean are generally older than rocks found in Northern Michigan
(D) Ages of rocks are not precise enough to determine which rock type is older

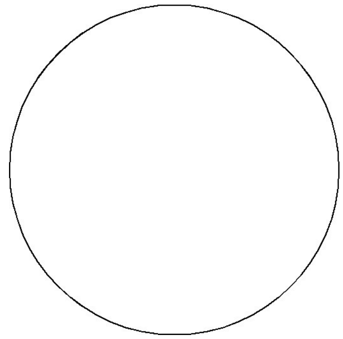
7. Tony has a black rock that he found at the National Mine that does not reflect light. He cuts it open and the inside is the same as the outside. Can Tony determine if this rock contains iron simply by looking at it?

(A) Yes. The rock is black and therefore does not contain iron
(B) Yes. If the rock contains iron, Tony would see silver specks in the rock
(C) Yes. Tony can use a microscope to see if the rock contains very small pieces of iron
(D) No. Tony would not be able to see if the rock contains iron, even with a microscope
(E) No. Tony cannot look at the rock since it does not reflect light and is therefore invisible

QUESTION 8 FOLLOWS ON NEXT PAGE

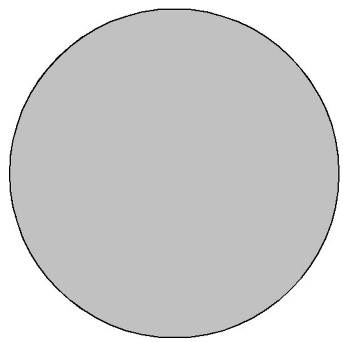
8. What did the Earth's surface look like when it first formed?

A. One large landmass surrounded by water

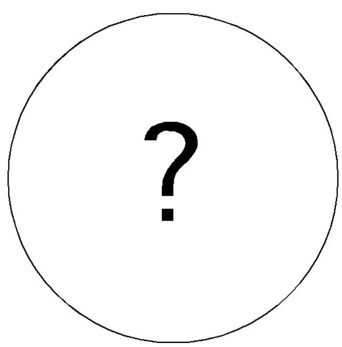


B. All water and no land

C. Similar to today



D. Mostly molten rock and no water



E. We have no way of knowing

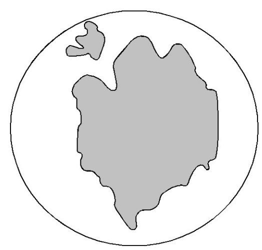
9. If you could travel back in time to when the Earth first formed as a planet, what would the state of Michigan look like?

(A) The Michigan would be mostly covered with water
(B) The Michigan would be mostly covered with molten rock
(C) The Michigan would be mostly covered with ice
(D) The Michigan would be mostly covered with solid rock

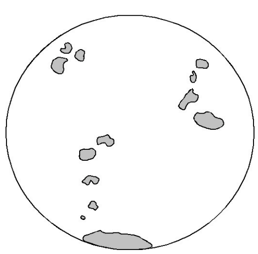
QUESTION 10 FOLLOWS ON NEXT PAGE

10. The figure below is a view of one-half of the Earth's surface as seen from space today. The gray areas represent land, and the white represents water. Which of the other figures do you think most closely represents this half of the Earth's surface when humans first appeared on Earth?

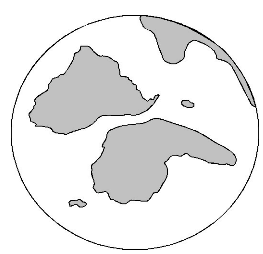
A



B



C



D

11. Looking at what we have seen in Michigan which of the following can greatly affect erosion rates? **Choose all that apply.**[2]

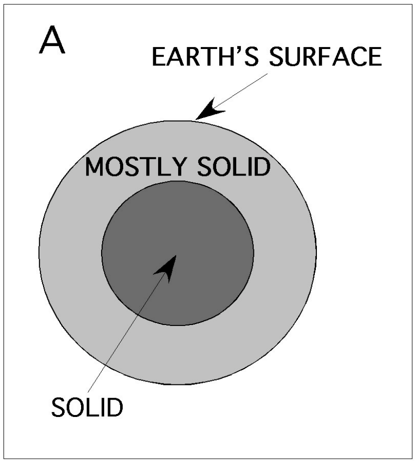
(A) Rock type
(B) Earthquakes
(C) Time
(D) Climate

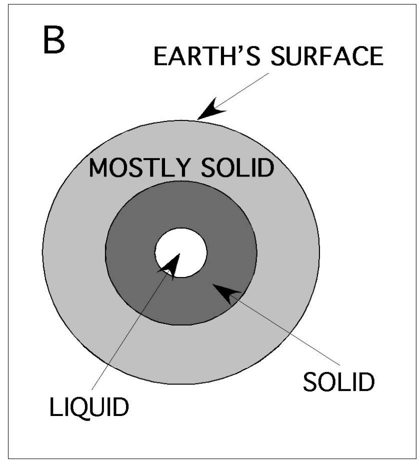
12. Rocks found in Lake Superior and the other Great Lakes can be _________. **Choose all that apply.**

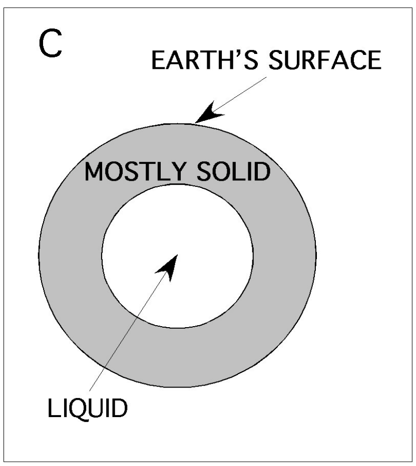
(A) Formed by animals
(B) Formed from continental rocks
(C) Formed by volcanic activity

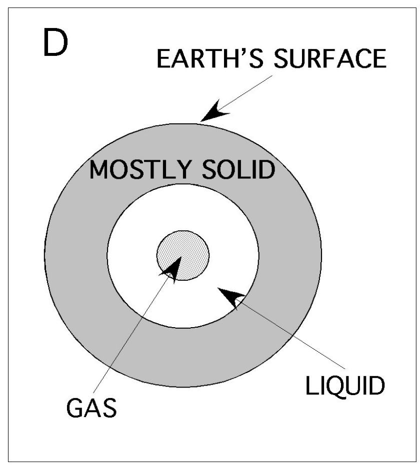
QUESTION 13 FOLLOWS ON NEXT PAGE

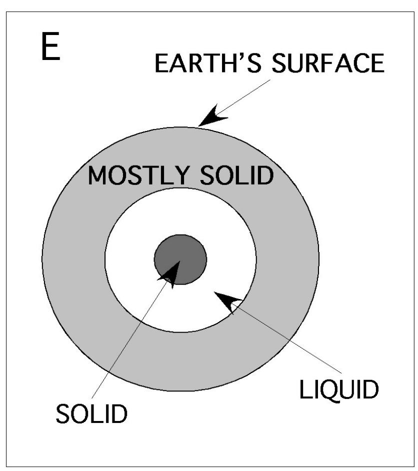
13. Which of the following figures do you believe is most closely related to what you might see if you could cut the Earth in half?



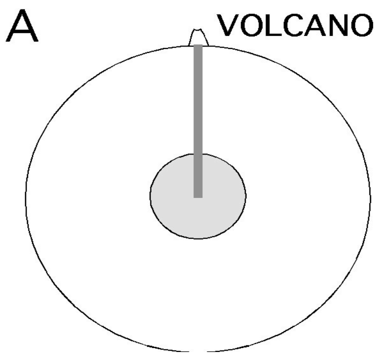




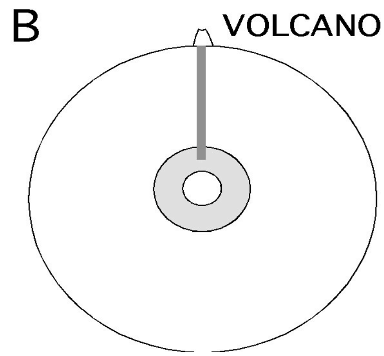




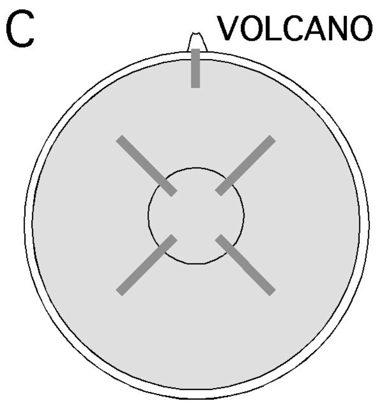
14. On continents, where does most volcanic material come from?



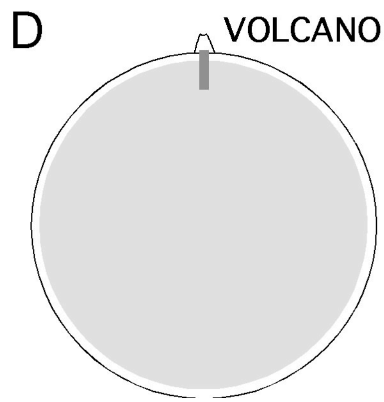
A. Material comes from the Earth's molten center



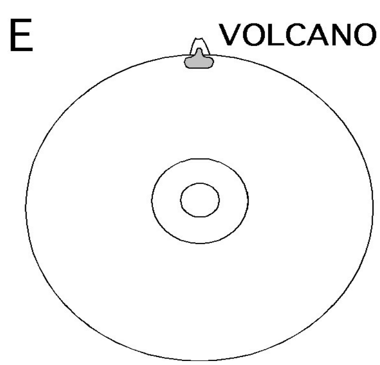
B. Material comes from a molten layer near the Earth's center



C. Material travels from the Earth's molten center and mixes with a molten layer beneath the Earth's surface



D. Material comes from a molten layer beneath the Earth's surface

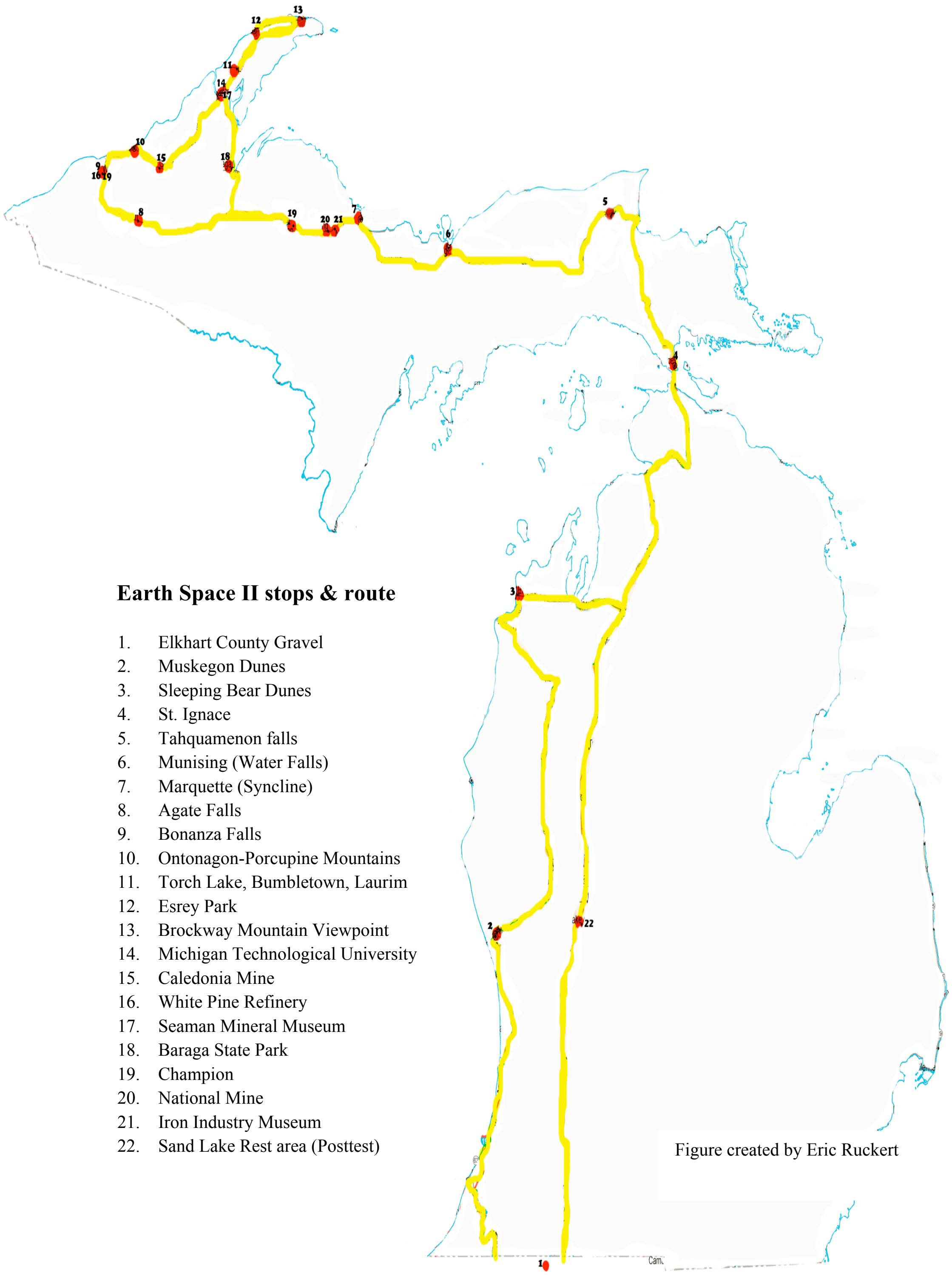


E. Material comes from pockets of molten material beneath the Earth's surface

15. Which is the best definition of a tectonic plate?

(A) All solid, rigid rock beneath the continents and above deeper, moving rock
(B) All solid, rigid rock beneath the continents and oceans and above deeper, moving rock
(C) All solid, rigid rock that lies beneath the layer of loose dirt at the Earth’s surface and above deeper, moving rock
(D) All solid, rigid rock and loose dirt beneath the Earth's surface and above deeper, moving rock
(E) The rigid material of the outer core

Appendix B: Route Map



Earth Space II stops & route
1. Elkhart County Gravel
2. Muskegon Dunes
3. Sleeping Bear Dunes
4. St. Ignace
5. Tahquamenon falls
6. Munising (Water Falls)
7. Marquette (Syncline)
8. Agate Falls
9. Bonanza Falls
10. Ontonagon-Porcupine Mountains
11. Torch Lake, Bumbletown, Laurim
12. Esrey Park
13. Brockway Mountain Viewpoint
14. Michigan Technological University
15. Caledonia Mine
16. White Pine Refinery
17. Seaman Mineral Museum
18. Baraga State Park
19. Champion
20. National Mine
21. Iron Industry Museum
22. Sand Lake Rest area (Posttest)
Figure created by Eric Ruckert

Appendix C: Informed Consent

INFORMED CONSENT FORM
EARTH SPACE II

(Based on Mills, G. (2007) *Action research: A guide for the teacher researcher, 3rd. Edition*. Upper Saddle River, NJ.: Pearson. p 111)

The information provided on this form and the accompanying cover letter is presented to you in order to fulfill legal and ethical requirements for Michigan Technological University (the institution sponsoring this master's degree study) and the Department of Health and Human Services (HHS) regulations for the Protection of Human Research Subjects as amended on March 26, 1989. The wording used in this form is utilized for all types of studies and should not be misinterpreted for this particular study.

My research report committee and the Institutional Review Board at Michigan Technological University, and the Research Review Committee of West Noble School Corporation have all given approval to conduct my study, "Assessment of High School Geological Field Course". The purpose of my study is to determine if Earth & Space II has increased students' knowledge of the listed educational objectives. This research will also seek to measure any impact Earth & Space II has had on students' attitude towards science.

Your child will be involved in this study by way of the following:

1. Pretest on Earth Science facts
2. Posttest on Earth Science facts
3. Journal entry
4. Completing of an Science Attitude Survey.
5. Field Course Activities (Camping, Hiking, Collecting Samples, Operation of GPS, Supervised Entry into areas of Geological Interest (Mines, Rock Piles, Scenic Overlooks).

All of these activities will be completed over a period of nine days. There are no foreseeable risks to the students involved. In addition, the parent or researcher may remove the student from my study at any time with just cause. Specific information about individual students will be kept *strictly confidential* and will be obtainable from the school principal if desired. The results that are published publicly will not reference any individual students since the study will only analyze relationships among groups of data.

The purpose of this form is to allow your child to participate in the study, and to allow the researcher to use the information already available at the school or information

obtained from the actual study to analyze the outcomes of the study. Parental consent for this research study is strictly voluntary without undue influence or penalty. The parent signature below also assumes that the child understands and agrees to participate cooperatively.

If you have additional questions regarding the study, the rights of subjects, or potential problems, please call the principal, Mr. Nate Lowe at 260-894-3191, or the researcher, Mr. Eric Ruckert at 260-894-3191 or email the researcher at ruckerte@westnoble.k12.in.us.

____

Student's Name

____________________________ ____________________

Signature of Parent/Guardian Date

The Michigan Tech Institutional Review Board (Michigan Tech-IRB) has reviewed my request to conduct this project. If you have any concerns about your rights in this study, please contact Ms. Joanne Polzien of the MICHIGAN TECH-IRB at 906/487-2902 or email jpolzien@mtu.edu.

Appendix D: Essay Test Scoring Tables

Criteria for Item 1 (1 point each) Waterfall	Points Given
Student shows understanding of relationship between gravity and water (1 pt)	
Evidence may vary but must be present (1 pt)	

Criteria for Item 2 (1 point each) Stream Flow	Points Given
Student shows understanding of relationship between gravity and flow of water in a stream.	
Student describes the relationship between and what happens to the streams flow and change in lake level.	
Evidence will vary but must be present	

Criteria for Item 3 (1 point each) Tides	Points Given
Student demonstrates factual knowledge (Yes, tides exist)	
Student provides evidence	

Criteria for Item 4 (1 point each) Surface Levels	Points Given
Student demonstrates factual knowledge. (levels drop)	
Student demonstrates an understanding of the relationship between glaciers and surface water.	
relationship between glaciers and surface topography	
Observable evidence is given	

Criteria for Item 5 (1 point each) (Great Lakes Compact)	**Points Given**
Student demonstrates the understanding of the relationship between groundwater and surface water.	
Evidence is given.	

Criteria for Item 6 (1 point each) (Hydrothermal Deposit)	**Points Given**
Student demonstrate an understanding of the deposition of copper by hot water	
Student understands that copper is deposited into existing rock.	
Provided observable evidence.	

Criteria for Item 7 (1 point each) (Mineral ID)	**Points Given**
Student states that they would use a mineral identification table	
Provides information on how to use identification table .	
Use physical properties of minerals in answer as evidence	

Criteria for Item 8 (1 point each) (Mine Process)	**Points Given**
Exploration defined.	
Example Exploration from course activities	
Extraction defined.	
Example Extraction from course activities	
Refining defined.	
Example Refining from course activities	
Reclamation defined.	
Example Reclamation from course activities	

Criteria for Item 9 (1 point each) (Quarries)	**Points Given**
Student demonstrates an understanding of the relationship between glaciers and quarries	
Example from course is given.	

Criteria for Item 10 (1 point each) (Hydrothermal)	**Points Given**
Student demonstrates an understanding of the hydrothermal deposition process and the relationship between deposits and mining.	
Example is given from evidence observed or collected during course.	

Criteria for Item 11 (1 point each) (Erosion Waterfall)	**Points Given**
Student understands the relationship between stream velocity and erosion.	
An example is given from the course.	

Criteria for Item 12 (1 point each) (U-Shape Valley)	**Points Given**
Student demonstrates an understanding of how glaciers erode and what landforms are left behind (u-shaped valley).	
They also relate it to observations made on the trip.	

Criteria for Item 13 (1 point each) (Dune Formation)	**Points Given**
Dry Sand (Factual)	
Land to deposit sand on (Factual)	
Wind to transport (Factual)	
Evidence is given from observations made during the course.	

Criteria for Item 14 (1 point each) (Dune Type)	**Points Given**
Dune is formed in same manner as all other dunes	
Describes a perched dune---above water	
Moraine is located under dune----or-----water levels lowered	
Evidence provided from course.	

Criteria for Item 15 (1 point each) (Fill in blank Finger Lake)	**Points Given**
Factual knowledge (Glaciers)	
Factual knowledge (Moraines)	

Criteria for Item 17 (1 point each) (Sand and Gravel)	**Points Given**
Factual Knowledge: Canada or Michigan (Anywhere north of Indiana)	
Factual Knowledge: Glaciers	
Observable evidence that supports answer is present.	

Criteria for Item 18 (1 point each) (Brockway Overlook)	**Points Given**
Erosion by glaciers is indicated as process	
Ridges are composed of more resistant rock.	
Observable evidence that support their answer is present.	

Criteria for Item 19 (1 point each) (Keweenaw Peninsula)	**Points Given**
Factual Knowledge---Shape of formation is indicated. Proper term is Syncline; however bowl or downward bending will work as well.	
Factual Knowledge—Convergent (May also say colliding)	
Observable evidence that support their answer is present.	

Criteria for Item 20 (1 point each) (Tectonic Plate—Waterfall)	**Points Given**
Student indicates that colliding tectonic plates caused rock to rise, bend, or deform.	
Student indicates that the increase in elevation resulted in the waterfalls.	
Observable evidence that support their answer is present.	

Criteria for Item 21 (1 point each) (Copper and Tectonics)	**Points Given**
Divergent plate boundaries caused deposition of igneous rock. (i.e. Magma is released to form basaltic rocks.)	
Convergent plates caused cracking of rock. (i.e. Cracks in rock caused by collision of plates or faults or bending)	
Remaining heat causes hot water to move through rock depositing copper and other minerals.	
Observable evidence that support their answer is present.	

Appendix E: Raw Data

Pre-Survey Raw Data Table					
Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
Learning Science In School					
We learn interesting things in science lessons.	0	1	1	8	5
I look forward to my science lessons.	0	2	0	8	5
Science lessons are exciting.	0	1	2	8	4
I would like to do more science at school.	0	0	3	8	4
I like Science better than most other subjects at school.	1	1	4	5	3
Science is boring.	0	1	3	6	5
It is exciting to learn about new things happening in science.	0	0	1	11	3
Lab work in Science					
Lab work in science is exciting.	0	0	8	3	4
I like science lab work because you don't know what will happen.	0	0	8	3	4
Lab work in science is good because I can work with my friends.	2	1	2	8	1
I like lab work in science because I can decide what to do myself.	0	0	4	8	3
I would like more lab work in my science lessons.	0	0	4	8	3
We learn science better when we do lab work.	0	2	5	7	0
I look forward to doing science lab.	0	0	0	12	3

Pre-Survey Raw Data Table (continued)

Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
Lab work in science is boring.	0	0	3	9	3
Science Outside of School					
I would like to join a science club.	1	3	5	4	2
I like watching science programs on TV.	0	4	3	5	3
I like to visit science museums.	1	1	4	5	3
I would like to do more science activities outside school.	0	1	2	10	2
I like reading science magazines and books.	1	5	4	4	1
Importance of science					
Science and technology is important for society.	0	0	0	5	9
Science and technology makes our lives easier and more comfortable.	0	0	1	11	3
The benefits of science are greater than the harmful effects.	0	0	10	4	0
Science and technology are helping the poor.	1	1	6	7	0
There are many exciting things happening in science and technology.	0	0	1	11	2
Self-Concept in Science					
I find science difficult.	0	6	4	5	0
I am just not good at Science.	1	7	6	1	0
I get good marks in Science.	0	1	3	10	1
I learn Science quickly.	0	4	5	6	0
Science is one of my best subjects.	0	4	2	6	3
I feel helpless when doing Science.	0	1	6	4	4

Pre-Survey Raw Data Table (continued)

Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
In my Science class, I understand everything.	0	6	6	3	0
Future Science					
I would like to study more science in the future.	0	0	4	8	3
I would like to study science at university.	0	1	4	8	2
I would like to have a job working with science.	0	5	4	4	2
I would like to become a science teacher.	1	6	7	1	0
I would like to become a scientist.	0	5	8	0	0
General Attitude Towards School					
Most of the time I wish I wasn't in school at all.	1	1	3	8	2
I get on well with most of my teachers.	0	0	0	9	6
I am normally happy when I am in school.	0	1	2	10	1
I work as hard as I can in school.	0	5	4	4	2
I really like school.	1	1	4	8	1
I would recommend this school.	1	1	4	8	1
I find school boring.	0	0	6	7	2
I feel that I belong in this school.	1	0	7	5	2
Mining and Inquiry					
I enjoy collecting rocks and minerals.	0	0	11	3	0
Mining is important for society.	0	0	7	7	1
Mining makes our lives easier and more comfortable.	0	0	8	6	1

Pre-Survey Raw Data Table (continued)					
Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
The benefits of mining are greater than the harmful effects.	0	5	7	3	0
I enjoy learning science by asking questions and answering my own questions.	0	1	3	7	4

Post-Survey Raw Data Table					
Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
Learning Science In School					
We learn interesting things in science lessons.	0	0	0	6	9
I look forward to my science lessons.	0	0	3	7	5
Science lessons are exciting.	0	0	3	7	5
I would like to do more science at school.	0	1	0	7	6
I like Science better than most other subjects at school.	0	1	6	5	3
Science is boring.	0	1	1	5	8
It is exciting to learn about new things happening in science.	0	0	0	12	3
Lab work in Science					
Lab work in science is exciting.	0	0	0	9	5
I like science lab work because you don't know what will happen.	0	0	3	8	3
Lab work in science is good because I can work with my friends.	2	2	5	5	1
I like lab work in science because I can decide what to do myself.	0	1	4	9	1

Post-Survey Raw Data Table (continued)

Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
I would like more lab work in my science lessons.	0	0	4	9	2
We learn science better when we do lab work.	0	0	3	9	3
I look forward to doing science lab.	0	0	1	11	3
Lab work in science is boring.	0	0	3	6	6
Science Outside of School					
I would like to join a science club.	0	2	6	4	2
I like watching science programs on TV.	0	3	5	4	3
I like to visit science museums.	0	0	2	8	5
I would like to do more science activities outside school.	0	0	2	10	2
I like reading science magazines and books.	1	1	5	7	1
Importance of Science					
Science and technology is important for society.	0	1	0	5	8
Science and technology makes our lives easier and more comfortable.	0	0	0	8	7

Post-Survey Raw Data Table (continued)					
Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
The benefits of science are greater than the harmful effects.	0	0	5	6	2
Science and technology are helping the poor.	0	1	6	7	1
There are many exciting things happening in science and technology.	0	0	0	9	6
Self-Concept in Science					
I find science difficult.	0	3	10	2	0
I am just not good at Science.	0	0	4	10	1
I get good marks in Science.	0	1	4	9	1
I learn Science quickly.	1	0	7	5	2
Science is one of my best subjects.	1	2	3	6	3
I feel helpless when doing Science.	0	1	3	10	1
In my Science class, I understand everything.	1	5	7	1	0

Post-Survey Raw Data Table (continued)					
Statement	Strongly Disagree 1	Disagree 2	Neither 3	Agree 4	Strongly Agree 5
Future Science					
I would like to study more science in the future.	0	0	3	8	3
I would like to study science at university.	0	0	5	8	2
I would like to have a job working with science.	0	2	6	5	2
I would like to become a science teacher.	1	3	4	6	0
I would like to become a scientist.	2	3	7	0	3
General Attitude Towards School					
Most of the time I wish I wasn't in school at all.	0	1	2	6	5
I get on well with most of my teachers.	0	0	1	8	6
I am normally happy when I am in school.	0	0	2	9	4
I work as hard as I can in school.	1	2	7	4	2
I really like school.	1	0	3	6	4
I would recommend this school.	0	1	4	5	5
I find school boring.	0	2	2	8	2
I feel that I belong in this school.	1	2	5	4	3
Mining and Inquiry					
I enjoy collecting rocks and minerals.	0	1	1	10	3
Mining is important for society.	0	0	1	10	4
Mining makes our lives easier and more comfortable.	0	0	2	11	2
The benefits of mining are greater than the harmful effects.	0	0	8	4	3
I enjoy learning science by asking questions and answering my own questions.	0	0	2	7	6

Pre Test: Geoscience Concept Inventory

ID #	Item #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Pts	%
94-12-01		1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	4	27%
94-12-02		1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	3	20%
44-10-03		0	0	0	0	1	1	0	0	0	0	1	0	1	1	0	5	33%
94-10-04		0	1	0	0	1	0	1	1	1	0	0	0	1	1	0	7	47%
44-11-05		0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	4	27%
94-12-06		0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2	13%
44-10-07		0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2	13%
94-10-08		0	0	0	0	1	0	0	0	1	0	1	0	1	1	0	5	33%
94-11-09		0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	3	20%
44-11-10		0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	4	27%
94-11-11		1	1	0	0	1	1	1	1	1	0	0	0	1	1	0	9	60%
94-12-12		0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	3	20%
94-10-13		1	1	1	1	1	0	0	0	0	0	0	1	1	1	0	8	53%
94-11-14		1	1	0	1	1	1	0	1	1	0	0	1	1	1	0	10	67%
94-11-15		0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	5	33%
	# Correct	5	6	1	2	12	4	3	6	5	4	3	3	12	8	0		
	% Correct	33%	40%	7%	13%	80%	27%	20%	40%	33%	27%	20%	20%	80%	53%	0%		
	STD	0.47	0.49	0.25	0.34	0.40	0.44	0.40	0.49	0.47	0.44	0.40	0.40	0.40	0.50	0.00		

Post Test: Geoscience Concept Inventory

ID #	Item #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Pts	%
94-12-01		1	1	0	0	1	0	0	0	0	0	0	0	1	1	1	6	40%
94-12-02		1	1	0	0	1	0	0	0	0	0	0	1	1	1	1	7	47%
44-10-03		1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3	20%
94-10-04		0	0	1	1	1	0	0	0	1	0	0	0	1	1	0	6	40%
44-11-05		0	1	0	0	1	0	0	1	1	1	0	0	0	1	0	6	40%
94-12-06		0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	3	20%
44-10-07		0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	4	27%
94-10-08		0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	8	53%
94-11-09		0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2	13%
44-11-10		0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	4	27%
94-11-11		1	1	0	0	1	1	0	1	1	0	0	0	1	1	1	9	60%
94-12-12		0	1	0	0	1	1	0	0	1	1	0	0	0	1	0	6	40%
94-10-13		1	1	0	1	1	0	0	1	1	0	0	0	1	1	0	8	53%
94-11-14		0	1	0	0	1	1	0	1	1	0	0	0	1	1	0	7	47%
94-11-15		0	0	0	0	1	0	0	1	1	1	0	1	1	1	1	8	53%
	# correct	5	11	2	3	15	4	0	6	8	4	1	2	10	10	6		
	% correct	33%	73%	13%	20%	100%	27%	0%	40%	53%	27%	7%	13%	67%	67%	40%		
	STD	0.471405	0.442217	0.339935	0.4	0	0.442217	0	0.489898	0.498888	0.442217	0.249444	0.339935	0.471405	0.471405	0.489898		
	ES	0.00	0.68	0.27	0.20	0.50	0.00	-0.50	0.00	0.42	0.00	-0.33	-0.17	-0.33	0.27	0.82		
% Gain		0%	33%	7%	7%	20%	0%	-20%	0%	20%	0%	-13%	-7%	-13%	13%	40%		

Essay Exam Posttest Raw Data

ID #	Item #	1	2	3	4	5	6	7	8	9	10	11
94-12-01		2	1	1	2	0	1	1	5	1	1	1
37-12-02		1	2	2	2	0	0	2	7	0	1	1
44-10-03		0	1	2	3	2	0	2	2	0	0	1
94-10-04		1	0	2	2	0	0	1	3	1	1	1
44-11-05		2	2	2	2	1	0	1	3	2	2	0
94-12-06		1	0	2	1	0	1	1	2	0	1	0
44-10-07		2	1	2	3	0	1	2	7	1	1	1
94-10-08		1	2	2	1	2	0	1	4	1	1	1
94-11-09		1	1	1	0	1	0	2	3	1	1	1
44-11-10		1	1	1	1	2	1	1	3	0	1	1
94-11-11		2	2	2	3	0	2	1	5	1	1	1
94-12-12		1	1	2	2	1	2	1	6	2	0	1
94-10-13		1	1	2	3	0	3	2	6	1	1	1
94-11-14		1	0	1	0	1	0	1	3	0	1	0
94-11-15		1	0	2	3	0	1	3	6	1	2	1
	Mean	1.27	1.16	1.76	1.84	0.60	0.84	1.56	4.18	0.91	0.93	0.71
	Pts Possible	2.00	3.00	2.00	4.00	2.00	3.00	3.00	8.00	2.00	2.00	2.00
	Mean Score	63%	39%	88%	46%	30%	28%	52%	52%	46%	47%	36%

Essay Exam Posttest Raw Data (continuted)

Item #	12	13	14	15	16	17	18	19	20	21	Mean
	1	3	3	2	2	2	2	1	1	2	
	2	3	2	0	3	3	2	2	2	3	
	2	3	0	0	0	2	0	2	0	2	
	2	3	2	2	2	2	2	1	2	3	
	2	3	1	2	1	2	1	2	1	1	
	0	2	2	1	0	2	0	1	1	1	
	2	3	3	2	2	3	2	3	2	2	
	2	3	2	2	3	3	1	3	2	2	
	1	3	0	2	2	3	2	3	2	2	
	1	3	3	2	1	0	2	1	3	0	
	2	3	4	2	2	3	0	2	3	2	
	2	3	2	2	2	2	1	2	2	1	
	1	3	3	2	2	3	3	1	2	3	
	2	3	2	2	1	2	1	2	1	2	
	1	4	3	2	2	2	0	1	2	3	
Mean	1.47	2.93	2.04	1.67	1.62	2.27	1.22	1.80	1.67	1.89	1.63
Pts Possible	2.00	4.00	4.00	2.00	3.00	3.00	3.00	3.00	3.00	4.00	
Mean Score	73%	73%	51%	83%	54%	76%	41%	60%	56%	47%	54%

Essay Exam Pretest Raw Data

ID #	Item #	1	2	3	4	5	6	7	8	9	10	11
94-12-01		0	0	0	1	0	0	0	0	0	0	0
37-12-02		0	0	0	0	0	0	0	0	0	0	0
44-10-03		0	0	0	0	0	0	0	0	0	0	0
94-10-04		1	0	0	0	0	0	0	0	0	0	0
44-11-05		0	0	0	0	0	0	0	0	0	0	0
94-12-06		0	0	1	0	0	0	0	0	0	0	0
44-10-07		0	0	1	0	0	0	0	0	0	0	0
94-10-08		1	0	1	0	0	0	0	0	0	1	0
94-11-09		0	0	0	0	0	0	0	0	0	0	0
44-11-10		0	0	0	0	0	0	0	0	0	0	0
94-11-11		1	0	0	0	0	0	0	0	0	0	0
94-12-12		0	0	0	0	0	0	0	0	0	0	0
94-10-13		1	1	1	0	0	1	0	0	0	0	0
94-11-14		1	1	0	0	0	0	0	0	0	0	1
94-11-15		0	1	0	0	0	0	0	0	0	0	0
	Mean	0.33	0.20	0.27	0.07	0.00	0.07	0.00	0.00	0.00	0.07	0.07
	Pts Possible	2.00	3.00	2.00	4.00	2.00	3.00	3.00	8.00	2.00	2.00	2.00
	Mean Score	17%	7%	13%	2%	0%	2%	0%	0%	0%	3%	3%
	Percent Gain	47%	32%	74%	44%	30%	26%	52%	52%	46%	43%	32%
	Total Points Possible = 64											

Essay Exam Pretest Raw Data (continued)

ID #	Item #	12	13	14	15	16	17	18	19	20	21	Mean
94-12-01		0	0	0	0	0	0	0	0	0	0	
37-12-02		0	0	0	0	0	0	0	0	0	0	
44-10-03		0	0	0	0	0	0	0	0	0	0	
94-10-04		0	0	0	1	0	0	0	0	0	0	
44-11-05		0	0	0	0	0	0	0	0	0	0	
94-12-06		0	0	0	0	0	0	0	0	0	0	
44-10-07		0	0	0	0	0	0	0	0	0	0	
94-10-08		0	0	0	0	0	0	0	0	0	0	
94-11-09		0	0	0	0	0	0	0	0	0	0	
44-11-10		0	0	0	0	0	0	0	0	0	0	
94-11-11		0	3	0	0	0	1	1	0	0	0	
94-12-12		0	0	0	0	0	0	0	0	0	0	
94-10-13		0	1	0	0	0	1	0	0	0	0	
94-11-14		0	0	0	0	0	0	0	0	0	0	
94-11-15		0	0	0	0	0	0	0	0	0	0	
	Mean	0.00	0.27	0.00	0.07	0.00	0.13	0.07	0.00	0.00	0.00	0.08
	Pts Possible	2.00	4.00	4.00	2.00	3.00	3.00	3.00	3.00	3.00	4.00	
	Mean Score	0%	7%	0%	3%	0%	4%	2%	0%	0%	0%	3%
	Percent Gain	73%	67%	51%	80%	54%	71%	39%	60%	56%	47%	51%
	Total Points P											