2021

Impact of inquiry science courses on preservice elementary students' ideas on science

Lance Charles Baetsle
University of Northern Iowa

Impact of inquiry science courses on preservice elementary students' ideas on science

Abstract

This study examines how students' scientific ideas compare between students who have taken different numbers of general science and inquiry science courses at a midwestern university. The purpose of this study is to gain perspective and to inform current teaching practices based on how preservice elementary education teachers view scientific ideas after taking a different number of inquiry science courses. Students in a science inquiry course completed a science survey (Appendix B) of science and non-science questions and were asked to explain their reasoning. A scoring rubric (Wilson et al., 2010) was used to apply a score for correct and incorrect claims as well as correct justification based on providing evidence and reasoning. While the results from a showed an upward trend in terms of correct responses as students progressed through both inquiry science and general science courses, the justification and science reasoning was lacking. A Kruskal-Wallis test showed a statistically significant relationship between the number of science courses and the scores on the science survey, H (3) = 9.313, P = 0.025. An additional Kruskal-Wallis test did not show a statistically significant relationship between the number of inquiry science courses and the scores on the science survey, H (2) =5.077, P = 0.079. Lastly, a Mann Whitney U test indicated that students seeking an endorsement in science teaching was not significantly higher than those who were not, U=151.00, p =0.789. These findings can have implications for university level inquiry science courses as well as inform my own instruction and advocacy for inquiry in my current school district.

IMPACT OF INQUIRY SCIENCE COURSES ON PRESERVICE ELEMENTARY

STUDENTS' IDEAS ON SCIENCE

An Abstract of a Creative Component

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Lance Charles Baetsle

University of Northern Iowa

July 2021

Abstract

This study examines how students' scientific ideas compare between students who have taken different numbers of general science and inquiry science courses at a midwestern university. The purpose of this study is to gain perspective and to inform current teaching practices based on how preservice elementary education teachers view scientific ideas after taking a different number of inquiry science courses. Students in a science inquiry course completed a science survey (Appendix B) of science and non-science questions and were asked to explain their reasoning. A scoring rubric (Wilson et al., 2010) was used to apply a score for correct and incorrect claims as well as correct justification based on providing evidence and reasoning. While the results from a showed an upward trend in terms of correct responses as students progressed through both inquiry science and general science courses, the justification and science reasoning was lacking. A Kruskal-Wallis test showed a statistically significant relationship between the number of science courses and the scores on the science survey, $H(3) = 9.313$, $P = 0.025$. An additional Kruskal-Wallis test did not show a statistically significant relationship between the number of inquiry science courses and the scores on the science survey, $H(2) = 5.077$, $P = 0.079$. Lastly, a Mann Whitney U test indicated that students seeking an endorsement in science teaching was not significantly higher than those who were not, $U=151.00$, $p = 0.789$. These findings can have implications for university level inquiry science courses as well as inform my own instruction and advocacy for inquiry in my current school district.

IMPACT OF INQUIRY SCIENCE COURSES ON PRESERVICE ELEMENTARY STUDENTS' IDEAS ON SCIENCE

A Creative Component

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Lance Charles Baetsle

University of Northern Iowa

July 2021

This Study by: Lance Baetsle

Entitled: Impact of Inquiry Science Courses on Preservice Elementary Education Students' Ideas on Science.

has been approved as meeting the creative component requirement for the

Degree of Master of Arts in Science Education

__________ ____

Date Dr. John Ophus, Creative Component Advisor

__________ ____

Date Dr. Kyle Gray, Creative Component Second Reader

TABLE OF CONTENTS

LIST OF TABLES

Introduction

Preservice elementary science teachers face a number of obstacles in their preparation in becoming science educators. On top of all the obstacles, there is a general expectation for elementary science teachers to learn techniques and methods needed for the science classroom and general education classroom settings. One heavily embedded component of the *Next Generation Science Standards* (NGSS) is inquiry learning, and this is detailed further in the science and engineering practices in *The Framework for K-12 Science Education* (National Research Council, 2012). Although the NGSS does not directly address how to teach science standards, it is often implied that teachers use some sort of inquiry-based learning as part of their three dimensional teaching and learning model. A preservice elementary science teacher may have their first exposure to this type of teaching and learning at the secondary level, but many may not get their first exposure until their college preparation program (Windschitl, 2003) . Universities can also offer specialized courses that teach content through an inquiry-based format, allowing students to have a hands-on perspective of inquiry teaching and learning. This paper will focus primarily on how the number of inquiry science courses impacts overall scores on a science survey (Appendix B), which can in turn be used as an indicator of student benefit from inquiry-based instruction.

Previous research has looked into the potential impact of science inquiry courses on preservice elementary education teachers (Yoon et al., 2012; Windschitl, 2003) . Inquiry science courses seem to benefit preservice elementary science teachers in a variety of ways including, but not limited to: understanding of the nature of science, attitude toward inquiry-based pedagogy, using inquiry in curriculum development, improving scientific argumentation and reasoning, etc. (Steinberg et al., 2015; Edgcomb et al., 2008; Acar, 2014; Sanger, 2008).

Understanding how preservice elementary education teachers use the knowledge and skills of inquiry learning can be of value to the current inquiry-based science courses at the University of Northern Iowa. This study can give educators at the university a snapshot of how students respond to science and non-science questions. The responses can give insight into the thought processes of students when tackling scientific and non-scientific inquiries, and if they are using the knowledge and skills gained from the inquiry science courses. The study can also be used at a personal level for my own classroom as well as being an avenue for necessary changes in my school district.

The purpose of this study is to compare how students who have taken a set number of science and/or inquiry science courses score on scientific and non-scientific questions. This comparison can be used to make inferences on the overall impact of inquiry-based instruction as well as a preservice elementary teacher's development in skills and knowledge needed in order to teach science in an inquiry-based fashion. The research questions for this study are as follows:

RQ1 - Do the total number of science courses taken by students influence science survey scores?

RQ2 - Do the total number of inquiry courses taken by students influence science survey scores?

RQ3- Do the scores differ between students who planned on getting a science endorsement or a science education minor compared to students who do not?

Literature Review

History of inquiry learning and the science classroom

One defining characteristic of humanity is our ability to observe phenomena and ask why. In the ancient past, inquiring about nature was merely a key to our survival, over time as human life became safer due to technology and the development of civilization, we began to also inquire more for the sake of curiosity. Inquiry learning can be traced back to the foundations of education. Roots of inquiry can be found in the socratic method employed by Socrates in ancient Greece (Friesen & Scott, 2013). The inquiry-like methods and ideas of ancient thinkers such as Socrates, Plato, and Aristotle were cemented into western civilization for over a millennium.

Science education in the United States has its roots in early academies, and during the 1800's academies began adopting science over the study of classical languages (DeBower, 1991). In the early 1900's, John Dewey encouraged using the ideas of inquiry-based learning as a primary teaching strategy in the classroom (Friesen & Scott, 2013). While these methods were encouraged, they were not looked at closely by science educators until 1957 when inquiry in the science classroom was introduced along with many other changes as a response to the successful launch of the Russian satellite *Sputnik*. (Chiapetta, Koballa, & Collette, 2002).

Along with this response came Jerome Bruner's revisions to Dewey's ideas and his ideas for a spiral curriculum and a structured form of discovery learning (Bruner, 1960, Bruner 1961). Bruner's concept centered heavily on students discovering ideas rather than relying on teachers giving information. With this idea, the teacher's role turned to a facilitator of the learning process instead of a direct provider of information. Although it was recommended by national committees to use inquiry in science classrooms, these ideas remained relatively dormant in american science classrooms until Joseph Schwab reintroduced them again in 1962 (Bybee, 1977; DeBoer, 1991). Schwab described the lack of inquiry in science classrooms as, "...being a failure of science teaching to keep pace with scientific development (DeBoer, 1991, p. 164-164)." The way scientists perceived scientific knowledge had transformed from rote memorization of facts to something that was flexible and could be revised when needed. Schwab felt that schools had held on to the former idea instead of changing with the times (Schwab & Brandwein, 1961).

Even though James Rutherford distinguished the two uses of inquiry as "inquiry of content" and "inquiry of pedagogy" (Rutherford, 1964), inquiry became a buzzword for science educators for the next three decades. Studies conducted during this time tended to use the term "inquiry" interchangeably in a few fundamentally different ways (DeBoer, 1991). One way inquiry was described at the time was as a necessary skill to learn as part of the nature of science, and the other as a particular method of teaching (DeBoer, 1991). In 1964, James Rutherford distinguished the two uses of inquiry as "inquiry of content" and "inquiry of pedagogy (Rutherford, 1964). Although inquiry science research in the 1960s, 1970s, and 1980s on science inquiry was a bit confusing to follow due to interchangeable uses of the term "inquiry" within science education research, a clear identity of inquiry as a method of teaching began to clearly emerge thereafter.

During the 1990s two reports outlining reforms of science education would begin to change the outlook for inquiry in the science classroom (Chiapetta, Koballa, & Collette, 2002). *Science for All Americans: Project 2061* (AAAS, 1990) was introduced in order to attempt to produce a scientifically literate society by the year 2061. The report called for students to understand the nature of science as well as the cultural and historical context of their discoveries. The committee responsible for the report did not provide or suggest ways students should be taught science as there are many approaches to effective science instruction. *The National Science Education Standards* (National Research Council, 1996) were introduced a few years later and would begin to heavily implement scientific inquiry into the foundation of the standards. The NSES defined scientific inquiry as:

> "The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Research Council, 1996, p.1)."

The *Next Generation Science Standards* (NGSS Lead States, 2013) were introduced in 2013 and were based on the *Framework for K-12 Science Education.* (National Research Council, 2012). The framework provided current research on science and science learning and identified what science concepts K-12 students should know. It also emphasised a three dimensional learning approach which includes disciplinary core ideas, science and engineering practices, and cross cutting concepts. The framework also specified exactly what is meant by scientific inquiry and has been embedded largely into the practices component of three dimensional learning. The framework chose to use the term practices rather than science processes or inquiry skills. "We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice." (National Research Council, 2012, p. 30) Within the science and engineering practices lives the very essence of inquiry, but it requires a basic background knowledge before it can be fully utilized. This is in the tradition of Jerome Bruner's findings in 1961, where he determined it is much more favorable for students to have some background knowledge about a subject opposed to giving students full reign before carrying out discovery learning. Bruner's ideas of a spiraling curriculum are also very prevalent in the NGSS as students continuously build on previous knowledge from kindergarten to twelfth grade. How modern educators use each component of the three dimensions and to what effect is currently an ongoing endeavor in science education in the United States.

Recent research on inquiry learning in the science classroom

A number of meta-analyses and individual studies since then have come to the conclusion that inquiry-based instruction can be a more effective way to help students gain better conceptual understanding of content (Furtak et al., 2012). A synthesis by (Minner, Levy, and Century, 2010) of one hundred and thirty eight studies showed a positive trend favoring inquiry-based instruction in the science classroom. While this study showed positive trends for inquiry-based science instruction for fifty-one percent of the studies, the trends for an investigation cycle (generating questions, design experiments, collecting data, drawing conclusions, and communicating findings) showed clearer positive trends for important skills such as student active thinking, drawing conclusions from data and student responsibility for learning (Minner, Levy, and Century, 2010). The hands-on aspect of inquiry learning and learning through phenomena also was linked to increased conceptual learning (Minner, Levy, and Century, 2010). A scaffolded approach may also be more effective in getting young students to observe a wider view of the evidence instead of accepting the first conclusion they come to. This goes along with the ideas of (Llewellyn, 2013) explaining that it is necessary to scaffold the levels of inquiry until students are comfortable carrying out investigations on their own. Current implementation of inquiry through the three dimensions of the NGSS and through other means is ongoing and future studies can help determine the amount of inquiry science implementation and its overall effectiveness in the K-12 environment.

Other meta-analyses of science inquiry show small benefits to both english language learners as well as special education learners (Estrella et al., 2018; Therrien et al., 2011). The consensus of these and other studies and meta-analyses has been enough for science inquiry to be endorsed as a useful method of instruction by a number of organizations in the United States including but not limited to: The National Science Foundation, The National Science Teaching Association, The National Research Council, and The National Academies of Sciences, Engineering, and Medicine. The support from these organizations along with the NSES and the NGSS both emphasizing the use of inquiry in the scientific process means that inquiry science is likely to be emphasized in science classrooms in the United States for a long time, if not indefinitely. Studies by (Wilson et al., 2010 and Geier et al., 2008) have also shown that science inquiry can also play a hand in closing the performance gaps for both race and gender on standardized tests.

Types of inquiry used in the science classroom and their applications

Although inquiry has taken on many different definitions over the years, the instructional version of inquiry will be used for the purpose of this study. Inquiry instruction is the method of instruction where students construct new ideas and concepts and improve their reasoning skills through exploration, term introduction, and concept development and application (Lawson, 2010). Science inquiry can be defined as: "the ways in which scientists study the natural world and propose explanations based on evidence as well as the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (National Research Council, 2000). Science inquiry can be characterized by five features: engaging students in scientifically oriented questions, giving priority to evidence in responding to questions, formulating explanations from evidence, comparing and evaluating explanations in light of alternative explanations, and communicating or justifying explanations (National Research Council, 2000). Since this study focuses on preservice elementary teachers, the ideas of inquiry science will pertain to the ideas of these preservice elementary teachers and how they use the above mentioned characterizations of science inquiry to justify their claims.

Types of inquiry can be broken down into categories based on the amount of scaffolding a teacher gives a student in order to carry out an investigation. While inquiry has been broken up by different authors (Banchi & Bell, 2008; Martin-Hansen, 2002), this study will use the categories developed by (Llewellyn, 2013) : Demonstrated inquiry, structured inquiry, guided/teacher initiated inquiry, and self-directed or student-initiated inquiry.

Each category of inquiry has elements that are introduced by either the student or by the teacher. Selecting which is appropriate depends on the student's previous experiences with inquiry learning as well as the content being taught. Demonstrated inquiry focuses on the phenomena for the learning cycle and usually reinforces a previously introduced idea, involves complex procedures, hazardous materials, expensive chemicals/equipment, or what Llewellyn calls a “discrepant event”, which is an unexpected event that goes against students expectations (Martin-Hansen, 2002 ; Brachi and Bell, 2008; Llewellyn, 2013). In this case the instructor has control over the question (phenomena), setting up the procedure, as well as how students communicate results. Provided that safety concerns can be handled, students should be able to explore the demonstration themselves and the instructor should carefully inquire about the phenomena along the way. Students will be able to be an active participant rather than merely an observer. This strategy can also be used for students with little to no experience with inquiry in order to get them to get used to the procedures and expectations that come with higher levels of inquiry (Llewellyn, 2013).

Llewellyn describes Structured Inquiries as inquiries that provide students with the driving question, procedure, and data tables, but students are required to create a chart or table to organize data and analyze findings and make inferences that can lead to new questions or investigations. In this style of science inquiry, the teacher has control over the question and procedure, but students have more control over explaining their results. While similar to traditional “cookbook labs” often seen in the science classroom, this type of science inquiry gives students more ownership over their learning by offering students more agency over how to analyze and share their ideas (Martin-Hansen, 2002 ; Brachi and Bell, 2008; Llewellyn, 2013).

Demonstrated and structured inquiry can be useful for when students need practice following directions or are inexperienced with science inquiry as behaving as a scaffold towards more independent styles of inquiry such as guided or self directed inquiry (Llewellyn, 2013).

Guided inquiry allows the teacher to provide a question and have students plan an investigation and share the results. This type of inquiry gives students much more choice in how to plan the procedure (Martin-Hansen, 2002 ; Brachi and Bell, 2008; Llewellyn, 2013). The teacher can give suggestions on how to proceed, but students have the opportunity to make independent choices on their procedure. This level of inquiry will likely require students to have previous experiences with inquiry in order to be successful as scaffolding can occur in lower levels in order to build necessary skills in developing procedures and explanations of results (Llewellyn, 2013). Self-Directed or Student Initiated Inquiries are when students take complete control over the entire inquiry process (Llewellyn, 2013). Students ask questions, set procedures, and share results and the teacher plays a facilitating role. In this role, students have the most control over their learning (Martin-Hansen, 2002 ; Brachi and Bell, 2008; Llewellyn, 2013).

While science inquiry learning can be a useful tool, it would be a mistake for a teacher to see the levels strictly as a straightforward progression (Llewellyn, 2013). Students who are not used to inquiry learning or the learning cycle will likely not be successful with self-directed inquiry as they have not built the necessary skills to develop their own questions, methods, and arguments. Educators looking to implement inquiry will likely have the most success by initially teaching the inquiry process through demonstrated and structured inquiry activities (Llewellyn, 2013). Teachers can use the types of inquiry that require less student interaction, such as demonstrated and structured inquiry, as a way to scaffold skills and ideas that will be beneficial for guided and self-directed inquiry activities.

Different types of lessons can require different types of inquiry in the science classroom (Marten-Hansen, 2002). For example, if a lab requires dangerous chemicals that can react unfavorably, a completely open investigation would not be appropriate as it can endanger the students. Other inquiry activities can require equipment that is not available to certain classrooms. Investigations that require specific scientific equipment may reduce ways students go about setting up their investigation if they do not have access to the necessary materials. Students who have not yet mastered the skills to be successful in demonstrated or structured inquiry will likely not be ready to handle guided or self-directed inquiry. This can be a result of many factors such as improper training, lack of maturity, cognitive ability, age of the students, etc. While inquiry learning can be very beneficial for all students, all educators should choose the appropriate type of inquiry-based on the needs and abilities of their students.

Preservice elementary education majors and science inquiry

Preservice elementary science teachers spend their time in college learning content and pedagogy, but many find it difficult to bridge the two together in a way that can help all students learn (Ball, 2000). At the same time, it can be expected that these students transfer from a position from a veteran student with often little science experience to a teacher that is capable of teaching through scientific inquiry. Preservice elementary science teachers develop their knowledge and skills in science teaching by learning how to engage students in science, learning about teaching strategies for science classrooms, and organizing lesson plans and curriculum.

Teaching science can be a difficult task for any teacher, it can be even more difficult for an elementary teacher that is required to teach multiple subjects, often certain subjects taking more precedence due to standardized testing.

Preservice elementary science teachers often gain the necessary knowledge for teaching inquiry during their methods courses, and elementary science teachers can have entire courses dedicated to learning how to teach and learn science in a more inquiry-based fashion. While universities can offer these experiences, the curriculum used by districts the teachers get hired by often need adaptations to become more inquiry-based (Forbes, 2011). The application of inquiry-based concepts largely falls on the teacher as they are responsible for making the best choices for educating their students. This is complicated further as teacher's beliefs on education do not always align with their implementation (Bryan, 2003).

Science educators in university education programs can play a key role in introducing science inquiry to preservice elementary teachers. A study conducted by Windschitl (2003) found that only around twenty percent of preservice science teachers surveyed in science teaching methods courses had classroom experiences in full inquiry. Many undergraduate science classes tend to emphasize content specific and fact based content over a scientific inquiry process that focuses on problem solving (Nugent et al., 2012). While this process is understandably done for the sake of efficiency, the question remains: If it is a goal for universities to develop science educators who have the knowledge and skills to teach through science inquiry, shouldn't science educators experience inquiry learning themselves in a college setting? Having the experience of learning science in an inquiry-based fashion has been helpful in preservice teachers moving towards using science inquiry in their own classrooms (Baxter et al., 2004; Newman et al., 2004). (Newman et al. 2004) states that a single semester course by itself may not be enough to give students all they need to teach adequately through science inquiry.

Science inquiry courses seem to help preservice science teachers in other regards as well. Inquiry science courses can also be helpful in preservice educators' perspective and favorability of inquiry teaching and learning (Steinberg et al., 2015). Inquiry science sequence can also be useful in increasing confidence in ability to teach science (Edgcomb et al., 2008) In addition, argumentation inquiry-based courses may increase both science argumentation ability as well as conceptual knowledge (Acar, 2014). Students seem to also benefit from science inquiry courses in both scientific reasoning (Acar, 2014; Edgcomb et al., 2008) and understanding the methods and nature of science (Sanger, 2008; Steinberg et al., 2015).

Theoretical Framework

Constructivists hold the worldview that learners are not passive receivers of knowledge, instead they make or construct knowledge through new experiences (Driver, Asoko, Leach, Mortimer, & Scott, 1994). This research was conducted within the worldview of radical constructivism. Radical constructivism states that knowledge is ultimately constructed from an individual's own experiences (Glasersfeld, 1995). For this study, students who participated in the inquiry-based courses learned together, but ultimately the knowledge and ideas required for answering the science survey questions was constructed by each individual based on their own experiences.

Constructivism allows for an explanation of how learners learn new things, but it does not tell us exactly how to teach. There are many tools in the constructivist toolbox, from Piaget's cognitive constructivism which focuses on the individual's cognitive changes to Vygotsky's social constructivism which focuses on cognitive changes based on social interaction (Vygotsky, 1962). Learning science can be done individually, socially, and in most cases a combination of the two (Driver et al. 1994). Kalina and Powell (2009) suggest both types of constructivism are important for teaching and learning. In order to learn science students need to individually change their previous ideas in order to construct new ideas, as well as engaging in discourse with others (Kalina & Powell, 2009; Driver et al. 1994). Although the student is inevitably responsible for their own learning, they also can be assisted through scaffolding by their instructor or peers. The instructor ultimately decides how this is done, and it is this author's opinion that instructors should choose a method that best fits the needs of the students.

Some are critical of constructivism in the science classroom stating that it may be a gateway for pseudoscience ideas (Mugaloglu, 2013). In constructivism, initial ideas of students are generally brought out into the spotlight, and sometimes these ideas fall within the realm of pseudoscience. Mugaloglu sees this as a possible exposure of pseudoscience ideas to students in the science classroom. Mugaloglu goes on to state that constructivism lends itself to a certain level of subjectivity or a notion of "viability within the subjects' experimental world Mugaloglu, 2013)." Since the individual is responsible for constructing knowledge, it goes without saying that there is a certain level of subjectivity that goes along with an individual's knowledge, which includes scientific knowledge. This subjectivity, according to Mugaloglu, can leave some wiggle room for non-science ideas to enter a scientific conversation. It is this author's opinion that constructivism can open a door for non-scientific science ideas, but it is up to the instructor to give students the tools to slam that door shut. It is up to science teachers to make sure that scientific and non-scientific ideas are not viewed with equal validity in the science classroom. As is often the case when handling misconceptions under a constructivist worldview, older ideas need to be brought into the light in order to be replaced with new ideas, but it is the job of the instructor to help students understand the how and why behind current scientific theories, including analyzing data and drawing conclusions. To this author, some criticisms of constructivism can be valid, but ultimately if the instructor presents new ideas to students who are willing to listen and have an open mind, then students will be able to construct new ideas. Under the framework of constructivism, it can be difficult to change old ideas if they are never brought in the open for discussion. Although constructivism opens the door for these ideas, it can just as well close them if new ideas are introduced and later accepted.

Why is this study important?

The basic science minor (K-8) at the University of Northern Iowa allows students to fill the requirements to gain endorsement for K-8 science in the state of Iowa. Inquiry science courses are part of the sequence for preservice educators to receive the minor. The results of this study may be beneficial for instructors of these inquiry courses and help understand how students' ideas of science evolve as they take these courses. It may also help instructors gain insight to how students tackle non-science ideas.

As a science educator, understanding the process of science inquiry in the context of my own classroom has helped me immensely. I have used the previous research on science inquiry as a foundation for planning my curriculum. Developing a student centered classroom with science inquiry at the core of my instruction has been the highest priority for me as an educator.

These methods are important for my day to day teaching and will likely be very beneficial for the duration of my career. The analysis of previous research as well as the historical context of both inquiry learning and science inquiry will help me make more informed decisions on how to structure lessons based on either inquiry-based or more traditional approaches. Not only that, but previous research can give me insight on what level of science inquiry is appropriate for certain situations. While the research I have conducted was carried out at a University level, the results of the benefits of inquiry-based learning can likely be used at a secondary level as well.

Students at all levels of academia have the opportunity to learn the process of science and its methods. Students should be able to use what they have learned to reject or at least question non-science ideas. In an era where students have access to more information than ever before comes the burden of students having access to more misinformation as well. The results of this study will be important for me to make decisions about my curriculum when it comes to the nature of science, methods of science, and argumentation from evidence, and how inquiry-based science activities can help bolster those ideas. The results of this study can also help me advocate for implementation of inquiry-based learning in my current district.

Methods

The current study utilized a correlation research design. Students surveyed were asked multiple choice questions pertaining to scientific and non-scientific inquiries. The students that participated in the survey were also asked to explain their reasoning for each question. Qualitative data was collected based on the responses and compared to the qualitative data from each question. Students were sent a voluntary request to participate in the survey via email from their class instructor. Students were directed to a survey link that included the consent form, demographics, and the survey.

Participants

The participants were thirty-six undergraduate elementary education students in introductory physical science, life science, and earth and space science courses at a mid-sized midwestern university. Thirty-four of the participants in this study self identified as female, while 2 participants self identified as male. The participants were between 18 and 22 years of age.

Materials

The institution's Internal Review Board approved the procedures for this study before student recruitment. A copy of the IRB approval form can be found in Appendix E. Students were administered the survey and copy of an approved consent form via electronic mail invitation. The survey consent form can be found in Appendix A and the survey questions can be found in Appendix B. A link redirected students to a separate survey website that included a description of the survey, a copy of the consent form, and the survey questions. In order to begin the survey, students were asked to accept the conditions presented in the description and the consent form. Students were allowed to quit the survey at any time by closing the tab or their internet browser.

Procedure

The participants (n=36) were enrolled in one of Inquiry into Life Science, Inquiry into Earth and Space Science, or Inquiry into Physical Science. These courses are inquiry-based science courses for elementary education majors that are required for their major or science endorsement. Participants completed the survey online using Survey Monkey® software. Faculty members not associated with the research provided an email with a link to the survey and a word document of the consent form for the participants' keeping.

Data Analysis

Scores for the science survey were calculated by using a combination of Likert scale responses as well as reasoning for their response. The science survey (Appendix B) contained modified questions from a twenty year longitudinal study by (Impey et al., 2011) which investigated science literacy among college undergraduates. A total of two points were awarded if the participant answered the question in a correct fashion in terms of agreeing or disagreeing with a statement. Up to three additional points were awarded based on the qualitative response (Appendix D). Scores for the qualitative response were determined by a scoring rubric used in a study by Wilson, et al. (2010) (Appendix C). The base score and the qualitative response score were combined into a composite score of up to five points and was calculated for each question and averaged for each participant.

Scores were then averaged and sorted into three categories in order to answer the research questions. Scores were sorted by number of inquiry science courses taken, number of science courses taken, and by student's plan on obtaining a science endorsement for K-8 or obtaining a science minor. The composite scores were analyzed using non-parametric statistics. A Kruskal-Wallis test was used to analyze research question one and research question two. A Mann Whitney U test was used to analyze research question three.

Results

Thirty-six participants completed the science survey. Two of the participants self identified as male, while thirty-four of the participants identified as female. The ages of the participants ranged between eighteen and twenty-two, the average age of the participants was 19.4 years. Of the thirty-six total participants, nine had no other previous college level science courses. Five students had completed all three inquiry science courses, six students had completed two inquiry science courses, and twenty-five students had just completed their first inquiry course (Table 1).

Table 1 .

Demographics of Participants researching Impact of Inquiry Science Courses on Preservice Elementary Education Students' Ideas on Science.

Characteristics	N	%
Gender		
Male	2	5.5
Female	34	94.5
Years in college		
First year	11	30
Second year	10	28
Third year	11	30
Four or more years	4	11
Number of college science courses taken		
One course	24	66.7
Two courses	5	13.9
Three or more courses	7	19.4
Students planning on receiving an endorsement in science	13	36.1

Research Question 1: Do the total number of science courses taken by students influence science survey scores?

Science survey scores (Appendix B) did increase from students taking one previous science course (14.43); however, they plateaued at 2 courses (26.71) and steadily decreased from 3 courses (25.67) to six courses (21.13) (Table 2). According to a Kruskal-Wallis test, the number of science courses did significantly influence the Science Survey Scores, H (3) = 9.313, P = 0.025.

Table 2.
Average Composite Science Survey Scores of Students Taking Previous Science Courses at the University of Northern Iowa

Number of Science Courses	N	Average Composite Score
1	22	14.43
2	7	26.71
3	3	25.67
4	0	-
5	0	-
6	4	21.13

Research Question 2: Do the total number of inquiry courses taken by students influence science survey scores?

Science survey scores increased from taking one inquiry science course (16.00) to taking 2 inquiry science courses (26.00), however, the scores then decreased from two inquiry science courses (26.00) to three inquiry science courses (22.00) (Table 3). According to a Kruskal-Wallis test, the number of inquiry science courses did not show a statistically significant influence on the Science Survey Scores, H (2) =5.077, P = 0.079.

Table 3.
Average Composite Science Survey Scores of Students Taking Inquiry Science Courses at the University of Northern Iowa

Number of Inquiry Science Courses	N	Average Composite Score
1	25	16.00
2	6	26.00
3	5	22.00

Research Question 3: Do the scores differ between students who planned on getting a basic science endorsement or a science education minor compared to students who do not?

Science survey scores differed slightly based on whether students were receiving a science endorsement. Students that did not plan on getting an endorsement scored lower (18.05) than those who were planning on getting an endorsement (19.06) (table 4). A Mann Whitney U test indicated that the scores of students seeking an endorsement (average) was not significantly higher than those students not getting an endorsement (average), U=151.00, p =0.789.

Table 4.
Mean scores for students that are planning on getting a science endorsement and students are not planning on getting a science endorsement.

Basic Science Endorsement	N	Mean Rank	Sum of Ranks
Plan on getting science endorsement	16	19.06	305.00
Do not plan on getting science endorsement	20	18.05	361.00

Quantitative results from the study showed a statistically significant relationship between the number of science courses taken and survey scores. These results were expected as students who take science courses should naturally be able to answer scientific questions based on information they would have learned in the course. Students should also be able to by convention be more equipped to successfully identify and explain away non-scientific claims as well. The data showed a slight decrease in average scores from three science courses to six science courses. Additional studies would be needed to address this further, as the number of participants who took fewer science courses (1-3) tended to be the majority ($n = 32$), while the number of participants who took more science courses (4-6) were significantly lower ($n = 4$), in addition, zero students in this range took 4 or 5 science courses. Having a larger sample size could help in determining if this observed trend is a pattern or an outlier.

Data from the study did not show a statistically significant relationship between the number of inquiry science courses and science survey scores. This result is surprising as previous research outlined in the literature review suggested that students who participate in inquiry learning should have the tools to think critically and therefore be able to more effectively reject unscientific claims and correctly identify and explain scientific claims. I would have expected to have seen comparatively higher scores from the number of inquiry science courses when compared to science courses taken. Although the data did not show a statistically significant relationship, it was reasonably close enough that further investigation of the topic may show a more definitive trend one way or another. Future studies may correct some larger issues with the methodology and design of this study which may have led to the mixed results of this study. The number of participants that completed the qualitative and quantitative portions of the study was relatively small. The total number of participants was a small sample size of the overall population of students taking these courses at any given time. The small sample sizes could have led to skewing of data when sorting the data by number of courses taken. Outliers in this scenario would have more impact on the results, and therefore additional studies with more participants would likely lead to more definitive results. Lastly, the science survey provided was based on surveys that compared science and non-scientific ideas and the scientific knowledge questions were primarily based on earth science and biology, so very few physical science questions were available. Further studies could include equal numbers of questions with content questions from each inquiry course (Inquiry Into Physical Science, Inquiry Into Life Science, and Inquiry Into Earth and Space Science) as well as questions based on non-scientific ideas.

Students who were planning on receiving their science endorsement did not show a significant statistical difference in scores on the science survey when compared to those who were not planning on receiving a science endorsement. I found this particularly interesting as I would have envisioned that studying a topic of interest would have led to better understanding of science topics and lead to better scores. The scores were surprisingly high, meaning that according to the data, there is almost no correlation between the two variables, and any comparison made between the two can be accounted for by random variation.

Impact of project on the classroom setting

The results from this study can have a positive impact in my own classroom as well as my school district as a whole. Some of the results are concerning for me as an educator as the scores from students who had no previous college experience were relatively low. Collectively, incoming students do not seem to have much ability to use the methods and ideas of science to disprove non-scientific ideas. Students did score moderately higher with questions that were linked directly to content they would have covered in a high school or introductory college level course. As we are in the midst of a technological revolution of how information is used and shared, it is this author's opinion that this generation's students will need to discern fact from fiction more than any generation that has come before. This includes the umbrella of science as well. Not only do students need to learn science as a content area in order to be successful, but they need to correctly understand the methods, processes, and nature of science to tell the difference between science and non-science. As part of the three dimensional model of the NGSS, thankfully these ideas are starting to take center stage in school science curriculum. It will be up to individual schools and educators to implement these in ways that are in the vision of the Framework for K-12 science education and the NGSS. While I remain optimistic about the proper implementation of the NGSS, I am skeptical about how evenly it will be implemented among all school districts. Focusing on a three dimensional model for my classrooms will be a top priority for me as an educator until my classes are truly three dimensional. Along with the three dimensions of the NGSS, I will also focus heavily on the nature and methods of science in my curriculum to support my students in developing necessary skills and knowledge to be successful scientific citizens.

The results of this study and the research I have conducted into the effectiveness of science inquiry in the classroom has cemented what I have observed over the past few years as an educator. A large portion of my students who I have taught science to through science inquiry have done better than they would have given more traditional means. Not only that, but the activities and meaningful connections to their lives has made courses more meaningful and impactful than they otherwise would have been. Inquiry science learning is easier the more exposure students have to it, so it is my hope that successes in inquiry science teaching will translate into other teachers adopting it as an option when planning curriculum.

Giving students the ability to have control over their learning can be intimidating, especially to students who are comfortable with the teacher having all control over learning. From personal experience, I have seen a subset of students be perfectly content in "playing school" in the way that it has been done through lecture and note taking in most secondary schools for decades. Any deviation from this format can lead some of the students to think that way of learning is inferior to traditional methods. For other students, learning can be an arduous task, and inquiry not only has the student explore an idea, but ask further questions, discuss openly, and practice in metacognitive reflection. As an educator, I can definitely see how the addition of cognitive tasks can make a student who generally struggles with school feel more intimidated. Keeping all of this in mind, I think the best way to go about introducing inquiry, especially to a population of students with no experience is to slowly give students more control over their learning over time, as suggested by Llewellyn (2013). I have used the previously discussed levels of inquiry in my own classrooms, so I have seen direct evidence of their practical application. I have noticed the most success in scaffolding the levels of inquiry according to Llewellyn (2013). While this process is not a clear switch that can be flipped over night, most of my students have been able to eventually grow the skills and knowledge needed to successfully carry out investigations with very little teacher guidance.

Through my experiences as an educator thus far, I have often seen evidence of a lack of understanding or implementation of inquiry throughout entire school districts. From my very limited perspective, implementation of the NGSS, and specifically the inquiry aspects of science have been spotty at best, and completely ignored at the worst. While it may be beneficial for my students at the high school level to have access to inquiry-based learning experiences, the system of a spiraling curriculum relies on all levels to have proper implementation in order to function. While the system at my current district is not perfect, I feel that I can use my research to be an advocate for more inquiry-based learning and argumentation throughout K-12 science.

Limitations of the study

Due to the number of participants as well as the number of qualitative responses by participants, this study can best be used as a snapshot for a specific population of students. More participation and qualitative responses would have likely led to more definitive results. As such, this study is unable to make any large sweeping claims about the overall effectiveness of inquiry science at the university level. It can, however, state that for this particular group of students, state that over time, students who take science courses are more likely to correctly answer scientific inquiries as well as be able to more likely reject non-science inquiries. Perhaps rephrasing the explanation portion into a claim, evidence, and reasoning format would yield clearer results. A greater number of complete responses would likely have led to a clearer understanding of student ideas on science topics and lead to more precise scoring. Participation for this study was completely voluntary, and was expressed as such by the instructors of the inquiry courses. The motivating factors for participation in this study were intrinsic, as no reward was given for participation. This might have had an impact on the sample pool for the study as well as the number of participants. The science survey was low risk and as a result, students may have not used the same effort in answering the questions as they would on an exam format. As the participants were all college students, the results may or may not be relevant to a K-12 setting. Further longitudinal studies would have to be conducted in order to see how science inquiry courses impact students at the K-12 level compared to college level students. While I did observe a pattern that more inquiry science courses led to higher scores on the science survey, further research is needed to express how rapidly these changes occur at all levels. This study also was only conducted post course completion, and could have possibly benefited from a pre/post comparison to see how students' ideas changed throughout course completion.

APPENDIX A

CONSENT FORM

The following survey is designed to ask the opinions on science related topics. By answering questions in this survey you will be assisting in research that can lead to better understanding of how students view and understand science. The data and results of this study will be used to aid in instruction for inquiry science courses at the University of Northern Iowa

Confidentiality statement: The data collected in this survey is confidential to the extent allowable by the technology used—that is, we can not guarantee confidentiality of information collected over the internet. We will not ask for any names or other direct identifiers, and we will only report results at the group level, so no one individual will be identifiable. After the study concludes, all data collected will be deleted and or discarded.

Statement of Risk: Potential risks of participation are very low. Risks while taking the survey may include, but are not limited to: minor discomfort, stress, and/or anxiety. While the risks for this survey are very low, you may opt out of taking the survey for any reason.

If the survey or participation in the study causes discomfort, stress, anxiety, etc. the University of Northern Iowa Counseling Center provides a variety of services. The services are free provided the student has paid the mandatory health fees.

The University of Northern Iowa Counseling Center

103 Student Health Center

Phone 319-273-2676

The survey contains 11 questions based on a 1 to 5 Likert scale. You will answer the questions based on how much you agree or disagree with the statement. You will also provide justification to why you selected your answer. The survey should take between 10-15 minutes to complete.

This survey is voluntary and you may opt out at any time. You are not required to take this survey as part of your coursework at the University of Northern Iowa and you will not receive academic credit or penalty for either taking or choosing to opt out. Only completed surveys will be used for data collection. If you complete the survey and decide you would not like to participate you may inform the survey administrator of your choice to not participate. The administrator can be contacted at:

lbaetsle@uni.edu

You must be 18 years or older to participate

APPENDIX B

SURVEY

Demographic Questions

Age:

Gender:

Year in college: (please circle)

1st 2nd 3rd 4th 5+ years

Do you plan on getting a basic science endorsement or science education minor? (please circle)

Yes No

Please place an X in the provided space if you have taken the following course(s).

_______Inquiry to Physical Science

_______Inquiry to Life Science

_______Inquiry to Earth and Space Science

Please list any other college level science courses you have taken:

____

____

____

____

____

____

Please answer the following questions to the best of your ability. Circle the response that best reflects your ideas.

1. Current climate change is due to manmade CO2 emissions that increase the intensity of the greenhouse effect.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

2. There is only one scientific method.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

3. A full moon makes people and animals behave differently.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

4. Humans evolved from earlier species of animals.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

5. Vaccinations can lead to autism.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

6. The Earth is between four billion and five billion years old.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

7. Aliens from other worlds built ancient monuments like pyramids because primitive humans could not have built them.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

8. Humans only use ten percent of their brains

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

9. Alternative medicine can work just as well as traditional medicine.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

10. The earliest humans lived at the same time as the dinosaurs.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

11. Humans are too complex to have come from natural processes, instead they must have arose from an intelligent designer.

Completely Agree	Somewhat Agree	Not sure at all	Somewhat Disagree	Completely Disagree
1	2	3	4	5

Briefly explain your reasoning:

APPENDIX C

QUALITATIVE REASONING SCORING RUBRIC

	0	1	2	3
Reasoning: A justification that links the claim and evidence, using appropriate and sufficient scientific principles.	Does not provide reasoning	Reasoning does not link evidence to claim. Scientific principles are missing, vague, or inaccurate. May rely on informal/non-scientific principles.	Reasoning links some of the evidence to the claim. Includes some, but insufficient scientific principles	Reasoning links multiple forms of evidence to claim. Includes appropriate and sufficient scientific principles.

From: Wilson, et al., 2010

APPENDIX D

QUALITATIVE RESPONSES SORTED BY QUESTION AND NUMBER OF INQUIRY SCIENCE COURSES TAKEN

Question 1 Responses

Current climate change is due to human made CO_2 emissions that increase the intensity of the greenhouse effect.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
Scientists say that this is a fact so I'm going to believe them.	1	3
Yes, we are impacting the environment but it is not as much as we think we are.	1	3
Not all climate change is happening from human made CO2, but most of it is.	2	3
While the earth goes through changes on its own all of the time throughout the span of many years, our current use of CO2 is responsible for the climate change we are experiencing, in my opinion.	2	2
The atmosphere that the Earth has causes a greenhouse effect and the CO2 is being emitted too fast before it can be converted into something else or stored. Because of the increased amount of CO2, the heat is kept inside the atmosphere longer and causing global climate changes.	3	2
Not all emissions are due to humans.	1	2
I believe there are other factors as well as this that are causing climate change.	1	2
Humans have a great impact on climate change and we should be taking steps to decrease our impact	1	2
It’s not just human made CO2 emissions. There are a lot more factors involved that are completely related to human involvement.	1	1
Climate change occurs naturally but human emissions have influenced the process and sped it up.	1	1
I remember learning about this in my Inquiry to Life Science class and I believe this statement above is true. Part of this issue may be caused by pollution, too.	1	1

Its not just CO2 that intensifys the affect of greenhouse effect its many other substances as well.	1	1
I know that climate change is mostly due to human made products and pollution, however, I am just unsure about the CO2 part of it.	1	1
It is definitely part of the cause, but I would not say that it is 100% of the issue.	1	1
I do not know much about how the greenhouse effect works. I do not get what the human-made CO2 means either.	1	1
I am not sure but I am assuming it has some effect.	1	1

Question 2 Responses

There is only one scientific method		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
Some methods have more steps or sequences throughout the entire course, but they all start the same way.	1	2
There is the main scientific method that every experiment loosely follows but every experiment is different and follows different steps.	1	0
There is a classic scientific method but different ways of phrasing it, but I think all of them have the same ideas involved.	1	2
I think that they have a scientific method to make sure that you understood what happened during the experiment and so it can be replicated.	1	3
It is a good guideline but there is no one way to solve a problem.	1	3
The method can be adapted to the experimentation.	1	1
There is probably more than one scientific method that can be used to solve an experiment, but there may be a format for scientific methods that are used frequently in the experimentation process.	2	1

There are many ways that ine can do an experiment its not a set order all of the time.	2	0
The scientific method can be described as a way to observe analyze and examine your findings	1	3
From the science class I'm currently in now (Chemical Technology), there is a definition for the scientific method. So there's only one.	1	0
There is always something that I do not know that is out there.	1	1
I would have to somewhat agree because I was taught only one way to do the scientific method. There could be more but I never learned any other way.	1	0
Many different versions, but virtually the same concept.	1	2
I don't have a lot of knowledge on this, but I have been taught the one scientific way. There is however always the chance that someone in the future can come up with a new scientific method.	1	2
There are many different steps to research something. The scienctific method is a general outline	2	2

Question 3 Responses

A full moon makes people and animals behave differently.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
I'm not sure if this is just a myth or reality honestly.	0	1
Full moons don't cause animals to act weirdly due to supernatural phenomena but animals may act differently since there is more light being produced on those days than others but in reality I'm not sure.	2	0
I feel like it's a common myth but I have never explored that. I hear teachers say it quite often but I haven't heard of a scientific explanation for it.	1	2
I work with kids I see a difference in their behavior every month, especially with children who have behavioral disabilities/challenges. I also know that	1	3

the word lunatic comes from the word lunar.		
The fact that many people think this subconsciously changes their actions and perceptions. I don't think it has a a direct effect on people and animals.	1	3
I don't know if this is true. I've heard of this theory before, but I have no clue.	1	1
Its a myth, it does not have any affects of people.	1	1
I know people say it does, but I believe I heard those stories are just made up or there's really no effect.	1	0
I mean... The moon affects water, and the human body is made up of a lot of water, so maybe?	1	0
I agree completely because when I went to my level ones, there was a full moon and every class in the school misbehaved that way. It is not a very accurate assumption but I do believe that.	1	1
I work at a daycare and always on a day of a full moon the babies are not themselves. (crying more often, not drinking their bottles, etc.)	1	0
I don't believe that the moon can affect your behavior.	1	2
I'm not sure why, but I think it does	1	2
I feel like this is just an assumption.	1	2
I don't think it affects people, but possibly animals	1	0

Question 4 Responses

Humans evolved from earlier species of animals.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
Humans are so scientifically similar to other species that it's almost impossible that we didn't evolve from them.	2	2
We did but not sure I completely agree with who or how they can find out where we came from.	1	0
I believe in micro evolution, that humans have changed over time and adapted to	1	2

their environment. But I think that humans were created by God and that we didn't evolve from a different type of animal.		
Science backs this up.	1	3
Evolution is real.	1	3
We weren't around before so we had to come from something that evolved.	2	1
I learned this in my Humanities class that humans have evolved from apes or chimpanzees. But on the other hand, I believe that God created us, human beings.	1	1
I believe that humans evolved from apes, we were not just brought into existence from nothing.	2	1
There's that famous picture showing apes slowing transforming/ evolving into a human/ man.	1	0
Where else would we have came? We have fossils to prove this don't we?	2	1
I do not believe in that because of my religion. I believe that God created all of us in his likeness and image.	1	0
God created Adam and Eve.	1	1
From gorillas	1	2
I believe that God put people on the earth, but I also think that we may have come from an animal. I think that Adam and Eve is merely a metaphor for what humans are supposed to do.	1	2
God made Adam and Eve.	1	2

Question 5 Responses

Vaccinations can lead to autism.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
It’s been scientifically proven that there is no link between the two.	1	2
This is just a worried mother who is overly protective of their child and by not giving them vaccinations they are putting their child at a greater risk of disease and death. She is also putting other children at risk. All it is, is an urban	1	0

legend that doesn’t have scientific proof to back it up.		
I haven't invested time into this topic so I can't say whether or not I agree or disagree.	1	2
There is no scientific evidence that vaccines cause autism.	1	3
Correlation not causation.	1	3
Where's the proof?	1	1
I don't think this is true. I think you may be born with a disability or if you happen to be in an accident of some sort, then you can be disabled from that. But I don't think that vaccinations lead to autism.	1	1
Research has proven that autism is not cause by vaccinations. It is a myth.	1	0
SO UNTRUE!!!	1	0
There is science behind this. If it does cause autism it is in extremely rare cases.	1	1
I am not very sure on this one because I do not know much about vaccines. Autism is a communication problem so I do not see how a vaccine can lead to that.	1	0
I am not very sure on this one because I do not know much about vaccines. Autism is a communication problem so I do not see how a vaccine can lead to that.	1	2
I have never heard of this before and cannot answer knowledgeably.	1	2
There is no evidence proving to this	1	2

Question 6 Responses

The Earth is between four billion and five billion years old.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
I think it may be a lot older than that.	1	2
As of right now we believe the earth is that old since that is as far back as evidence takes us.	1	0
The Earth is 4.6 billion years old	1	0

I believe in a God that transcends time and I think He could have created the world instantly or He could have chosen to take 4.6 billion years to create the Earth. Time is a human characteristic so maybe in earthly years it took 4.6 billion years but to God that's infinite, that's nothing. So yeah, I guess it could have, I don't really know how old the Earth is for sure but I think it could be that old.	1	2
I learned this in my Inquiry to Earth and Space Science class I am currently in, so I think this is true. But how do we know the Earth is this old? If God created the universe, when did all that happen?	1	3
I believe it is more like 7 billion? I'm not sure off of the top of my head	1	3
I used to know how old the earth is, I think 4-5 billion is correct.	1	1
I agree with this because I have been taught this since the fourth grade. I will not change my mind unless there is a big piece of evidence claiming otherwise	1	1
~4.6 billions years old.	1	0
Based on what I have studied in class this makes sense.	1	1
TRUE	1	0
I was told this in my science class (I think it was this number)	1	2

Question 7 Responses

Aliens from other worlds built ancient monuments like the pyramids because primitive humans could not have built them..		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
I don't know anything about this.	1	2
Humans have always been capable of building these structures during those times. The reason this theory still persists is because there was a period where humans seemed to lost knowledge of basic city building principles after the Roman Empire collapsed and most of the writings were destroyed or unreadable.	2	0

I think humans are innovative and motivated to do crazy things. I don't see how the pyramids could be any different.	1	2
The pyramids were built by people.	1	3
I'm not opposed to this idea but I do think that they were built by humans.	1	3
Aliens might exist, but so does engineering.	1	1
I don't really know how to answer this question. There may be some form of alien out there in the universe. Anything is possible. But I don't think aliens built the pyramids.	1	1
Extraterrestrial beings did not create the pyramids, ancient civilizations utilized technology they had to create them.	1	0
Garsh darn conspiracy theorists. I refuse to fight with stupid.	1	1
I do not believe in this because I have been taught since middle school that there were people in ancient times who built the pyramids. There is evidence of it as well.	1	0
I think that their had to have been some humans evolved enough and during that time to be able to build them.	1	2
I don't believe in aliens.	1	2
This sounds crazy	1	2
I don't believe in aliens/	1	2
That sounds ridiculous	1	1

Question 8 Responses

Humans only use ten percent of their brain.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
There’s so much of our brain we haven’t even discovered. It’s the most complex organ we have!	1	2
Humans use more than just 10% of their brains.	1	0
I think our brains are always completely in use but I don't think we cognitively use them to the best of our abilities. I think they have more power than what we use them for.	1	2

You use more than ten percent of your brain during certain tasks.	1	3
We use more than that using basic functions like breathing and heartbeat.	2	3
We may only use 10% for certain functions, but we use all of it.	1	1
I don't know about this question either. I guess people can choose to use all of their brain somedays or not at all other days. I think it just depends on what you do every day.	1	1
Some humans are able to access more than 10 percent of their brains, however the average human can only access 10 percent of their brains functions.	1	0
In high school psychology, we talked about this and how it was untrue.	1	0
Pretty sure our brain is more active than that even when we are sleeping.	2	1
I would just have to say I somewhat agree because of technology, people are so caught up in it and not what is around them.	1	0
I feel like some use more or less than that ten percent.	1	2
The brain is so powerful and I think that humans don't even know the power that they have in their brains.	1	2
It's what i've been told.	1	2

Question 9 Responses

Alternative medicine can work just as well as traditional medicine.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
Depends on the alternative medicine. Modern medicine is very powerful but can cause a lot of side effects that herbal remedies might not cause.	1	0
I think that things like acupuncture can sure help. It might be a placebo effect but if it works for the patient, then who cares how they get relief?	2	2
I think in some cases alternative medicine can work. I think it is a great first option. I would also argue that "alternative" medicines and treatments	1	3

are the original traditional medicine. They were used for years. I also think that when "traditional" medicine is needed it should be used in conjunction with "alternative" medicines.		
I have heard of both making a difference which is what matters.	1	3
I don't know about this question. I know that the medicine is changing for the better. For example, scientists are trying to find a cure for cancer. But I don't know if alternative medicine works just as good as traditional medicine.	1	1
I put in the middle because I feel like it just depends on what you're treating or what the medicine is being used for.	1	1
It honestly depends on what it is. If it works it works, even if it might only work as a placebo.	1	0
I am not sure because I do not know much about different kinds of medicines.	1	1
I haven't seen a ton of hard facts on either side of this yet.	1	0
Different people have different things that work for them. Sometimes there are things that medicine cannot fix.	1	2
Sometimes oils and things like that work, but I'm not sure if it's a placebo	1	2

Question 10 Responses

The earliest humans lived at the same time as the dinosaurs.		
Qualitative Response	Score	Number of Inquiry Science Courses Taken
I believe there were caveman especially since there has been proof that cavemen could have lived during that time.	1	0
I can't say for sure because I wasn't there, but I think that they could have, especially before Adam and Eve sinned. Once sin entered the world then things couldn't get along harmoniously anymore and I think that's when dinosaurs went extinct.	1	2
There is no proof of that.	1	3
There isn't evidence for that.	1	3

Mass extinction caused the evolution of mammals into human forms after the majority of dinosaurs lived.	2	1
I don't know about this question. I do think that cavemen were around some time and dinosaurs were around another time, but I'm not sure if they were living together at the same time.	1	1
Ancestors of humans were not around, therefore humans could not have existed during this period of time.	2	0
There weren't humans until much later	2	0
Totally not sure, but that brings up the possibility of someone having a pet dinosaur, and that is freaking awesome.	1	1
I somewhat agree because God created Adam and Eve around the same time. I am using my religious beliefs as well again.	1	0
I don't really think that it would have been good if dinosaurs and humans lived together, but I know that there were humans on earth way before dinosaurs.	1	2
Dinosaurs came first	1	0

Question 11 Responses

Humans are too complex to have come from natural processes, instead they must have come from an intelligent designer.

Qualitative Response	Score	Number of Inquiry Science Courses Taken
While i love to think Science is the cause for our existence, it is just so hard to believe that there isn't something that created living things in the first place. I know we evolved but what created the initial living thing??	1	2
I believe there is a God who created the universe and all life on Earth but at the moment there is no scientific proof to back any of these claims up.	1	0
I don't see how the mathematical probability would all align so perfectly for humans to be able to do what we do. We are incredibly complex creatures and different from all other animals. Plus, knowing that I was created by a divine being is a lot more comforting than if I think it's by chance. Even if I wasn't sure in a God, I would much rather put my	1	2

faith and eternity into something that wanted me to be alive and thrive rather than that I happened to evolve from an ape.		
I believe in evolution one hundred percent I think that we evolved from animals. However, I do believe in God and I believe that evolution was created by God.	1	3
I don't believe that we came from an intelligent designer unless they planned for us to evolve.	1	3
Evolution has allowed humans to develop their cognitive abilities over time.	2	1
I do believe that God created us to be on this Earth for a purpose. I know science disagrees with how the universe started, but I believe in the way God created us.	1	1
Humans went through evolution to get to the point were we are today rather tha "being created"	2	0
I'm not sure what an intelligent designer is but I definitely don't think humans are too complex.	1	0
God? Evolution? Who knows? If something as wonderful, kind, and intelligent as a dog can be evolved, then why cant humans, even if we aren't as great as dogs :)	1	1
The intelligent designer would be God. He created the whole world including people, animals, and nature. I do not know how not everyone gets this.	1	0
I believe that God was the "intelligent designer".	1	2
I think that God created everything	1	2
God is the intelligent designer	1	2
God is real	1	0

APPENDIX E IRB APPROVAL

UNI University of Northern Iowa

Lance Baetsle <lbaetsle@uni.edu>

HP #17-0212

6 messages

Helen Harton <helen.harton@uni.edu> Wed, May 3, 2017 at 3:51 PM
To: Lance Baetsle <lbaetsle@uni.edu>, John Ophus <john.ophus@uni.edu>, Anita Gordon <anita.gordon@uni.edu>

Lance,

I've read your IRB protocol. There were a couple of items that were missing or confusing in your consent form. I made some suggested changes using track changes. If you are okay with using the version I'm sending, your study is approved (exempt from continuing review, category 2). If you want to reword things, that's fine. We'd just need to see that before you send it out. I will try to do a quick turnaround as the semester is ending. Please send a quick return email saying which option you prefer.

Thanks, and good luck with your study,
Helen
Helen C. Harton, Ph.D.
Professor of Psychology
Graduate Coordinator
University of Northern Iowa
Cedar Falls, IA 50614-0505
319-273-2235

4-20c IRB 0212 Baetsle (Ophus), Rev..doc
130K

Lance Baetsle <lbaetsle@uni.edu> Fri, Sep 15, 2017 at 11:26 AM
To: Helen Harton <helen.harton@uni.edu>

Helen,

I attached and updated my consent form and am ready to distribute my survey. Just let me know if I have the go ahead on your end and I can get it started.

Thanks

Lance Baetsle

Consent Form

[Quoted text hidden]

Helen Harton <helen.harton@uni.edu> Tue, Sep 19, 2017 at 12:24 PM
To: Lance Baetsle <lbaetsle@uni.edu>, John Ophus <john.ophus@uni.edu>, Anita Gordon <anita.gordon@uni.edu>

Lance,

Your study is approved. Using this consent form, you can start collecting data!

Helen

Helen C. Harton, Ph.D.
Professor of Psychology
Graduate Coordinator

University of Northern Iowa
Cedar Falls, IA 50614-0505
319-273-2235

[Quoted text hidden]

Anita M Gordon <anita.gordon@uni.edu> Sun, Sep 24, 2017 at 5:08 PM
To: Lance Baetsle <lbaetsle@uni.edu>

Lance - I need a copy of your final consent form as well, and I can't access the google file below. Please attach a copy to your reply.

Thanks!

Anita Gordon
[Quoted text hidden]

--
Anita M. Gordon, PhD
Director of Research Ethics
Office of Research & Sponsored Programs
213 East Bartlett
University of Northern Iowa
Cedar Falls, IA 50614-0394
(319) 273-6148

Lance Baetsle <lbaetsle@uni.edu> Thu, Sep 28, 2017 at 3:26 PM
To: Anita M Gordon <anita.gordon@uni.edu>

Here you go!
[Quoted text hidden]

Consent Form.docx
6K

Anita M Gordon <anita.gordon@uni.edu> Fri, Sep 29, 2017 at 9:47 AM
To: Lance Baetsle <lbaetsle@uni.edu>

Thanks again!
[Quoted text hidden]

University of Northern Iowa
Cedar Falls, IA 50614-0505
319-273-2235

[Quoted text hidden]

Anita M Gordon <anita.gordon@uni.edu> Sun, Sep 24, 2017 at 5:08 PM
To: Lance Baetsle <lbaetsle@uni.edu>

Lance - I need a copy of your final consent form as well, and I can't access the google file below. Please attach a copy to your reply.

Thanks!

Anita Gordon
[Quoted text hidden]

--
Anita M. Gordon, PhD
Director of Research Ethics
Office of Research & Sponsored Programs
213 East Bartlett
University of Northern Iowa
Cedar Falls, IA 50614-0394
(319) 273-6148

Lance Baetsle <lbaetsle@uni.edu> Thu, Sep 28, 2017 at 3:26 PM
To: Anita M Gordon <anita.gordon@uni.edu>

Here you go!
[Quoted text hidden]

Consent Form.docx
6K

Anita M Gordon <anita.gordon@uni.edu> Fri, Sep 29, 2017 at 9:47 AM
To: Lance Baetsle <lbaetsle@uni.edu>

Thanks again!
[Quoted text hidden]

WORKS CITED

Acar, Ö. (2014). Scientific reasoning, conceptual knowledge, & achievement differences between prospective science teachers having a consistent misconception and those having a scientific conception in an argumentation-based guided inquiry course. *Learning and Individual Differences*, *30*, 148–154.

AAAS, (1990). *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology*. American Association for the Advancement of Science.

Ball, D. L. (2000). Bridging Practices: Intertwining Content and Pedagogy in Teaching and Learning to Teach. *Journal of Teacher Education*, *51*(3), 241–247.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children*, *46*(2), 26.

Baxter, B. K., Jenkins, C. C., Southerland, S. A., & Wilson, P. (2004). Using a multilevel assessment scheme in reforming science methods courses. Journal of Science Teacher Education, 15, 211-232.

Bruner, J. (1960). The Process of Education. Cambridge, MA: The President and Fellows of Harvard College.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, *31*, 21–32.

Bryan, L. A. (2003). Nestedness of beliefs: Examining a prospective elementary teacher's belief system about science teaching and learning. *Journal of Research in Science Teaching*, *40*(9), 835–868.

Bybee, R. W. (1977). The New Transformation of Science Education. *Science Education*.

Chiapetta, E. L., Koballa, T. R., & Collette, A. T. (2002). Science instruction in the middle and secondary schools. *Upper Saddle River, NJ: Prentice-Hall*.

DeBoer, G. E. (1991). *A History of Ideas in Science Education: Implications for Practice*. Teachers College Press, 1234 Amsterdam Avenue, New York, NY.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing Scientific Knowledge in the Classroom. *Educational Researcher*, Vol. 23, p. 5.

Efron, S., & Ravid, R. (2013) *Action Research in Education: A Practical Guide.* The Guilford Press.

Edgcomb, M., Britner, S., McConnaughay, K., & Wolffe, R. (2008). "Science 101: an integrated, inquiry-oriented science course for education majors." Journal of College Science Teaching, vol. 38, no. 1, 2008, p. 22

Estrella, G., Au, J., Jaeggi, S. M., & Collins, P. (2018). Is Inquiry Science Instruction Effective for English Language Learners? A Meta-Analytic Review. *AERA Open*, *4*(2).

Forbes, C. T. (2011). Preservice elementary teachers' adaptation of science curriculum materials for inquiry-based elementary science. In *Science Education* (Vol. 95, Issue 5, pp. 927–955).

Friesen, S., & Scott, D. (2013). Inquiry-based learning: A review of the research literature. *Alberta Ministry of Education*, *32*.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and Quasi-Experimental Studies of Inquiry-Based Science Teaching: A Meta-Analysis. *Review of Educational Research*, *82*(3), 300–329.

Geier, R., Blumenfeld, P. C., Marx, R. W., Krajcik, J. S., Fishman, B., Soloway, E., & Clay-Chambers, J. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. In *Journal of Research in Science Teaching* (Vol. 45, Issue 8, pp. 922–939).

Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning*. London: Falmer Press.

Impey, C., Buxner, S., Antonellis, J., Johnson, E., & King, C. (2011). A twenty-year survey of science literacy among college undergraduates. *Journal of College Science Teaching*, *40*(4), 31–37.

Kalina, C., & Powell, K. C. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education*, *130*(2), 241–250.

Lawson, A. E. (2010). *Teaching Inquiry Science in Middle and Secondary Schools*. SAGE.

Llewellyn, D. (2013). *Teaching High School Science Through Inquiry and Argumentation*. Corwin Press.

Martin-Hansen, L. (2002). Defining Inquiry: Exploring the many types of inquiry in the science classroom. *The Science Teacher, 69*(2), 34-37. Retrieved March 14, 2021, from http://www.jstor.org/stable/24154746

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *47*(4), 474–496.

Mugaloglu, E. Z. (2013). The Problem of Pseudoscience in Science Education and Implications of Constructivist Pedagogy. *Science & Education*, *23*(4), 829–842.

National Research Council. (1996). Division of Behavioral and Social Sciences and Education, Board on Science Education, & National Committee on Science Education Standards and Assessment. *National Science Education Standards*. The National Academies Press.

National Research Council. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. The National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for K-12 Science Educaiton Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Newman, W. J., Jr., Abell, S. K., Hubbard, P. D., McDonald, J., Otaala, J., & Martini, M. (2004). Dilemmas of teaching inquiry in elementary science methods. Journal of Science Teacher Education, 15, 257-279.

NGSS Lead States (2013). *Next Generation Science Standards: For States, By States*. National Academies Press.

Nugent, G., Toland, M. D., Levy, R., Kunz, G., Harwood, D., Green, D., & Kitts, K. (2012). The Impact of an Inquiry-Based Geoscience Field Course on Pre-service Teachers. *Journal of Science Teacher Education*, *23*(5), 503–529.

Rutherford, F. J. (1964). The role of inquiry in science teaching. *Journal of Research in Science Teaching*, *2*(2), 80–84.

Sanger, M. J. (2008). How Does Inquiry-Based Instruction Affect Teaching Majors' Views about Teaching and Learning Science? *Journal of Chemical Education*, *85*(2), 297–302.

Schwab, J. J., & Brandwein, P. F. (1962). *The teaching of science as enquiry*. Cambridge, Mass: Harvard Univ. Pr.

Steinberg, R., Wyner, Y., Borman, G., & Salame, I. I. (2015). Targeted courses in inquiry science for future elementary school teachers. *Journal of College Science Teaching*, *44*(6)

Therrien, W. J., Taylor, J. C., Hosp, J. L., Kaldenberg, E. R., & Gorsh, J. (2011). Science Instruction for Students with Learning Disabilities: A Meta‐Analysis. *Learning Disabilities Research & Practice: A Publication of the Division for Learning Disabilities, Council for Exceptional Children*, *26*(4), 188–203.

Vygotsky, L. (1962). Thought and language (E. Hanf-mann & G. Vakar, Trans.).. Cambridge, MA: MIT Press.

Wilson, C. D., Taylor, J. A., Kowalski, S. M., & Carlson, J. (2010). The relative effects and equity of inquiry‐based and commonplace science teaching on students' knowledge, reasoning, and argumentation. *Journal of Research in Science Teaching*, *47*(3), 276–301.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education*, *87*(1), 112–143.

Yoon, H.-G., Joung, Y. J., & Kim, M. (2012). The Challenges of Science Inquiry Teaching for Pre-Service Teachers in Elementary Classrooms: Difficulties on and under the Scene. *Research in Science Education*, *42*(3), 589–608.