Evaluating Inquiry-Based Learning as a Means to Advance Individual Student Achievement

by
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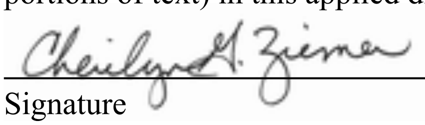

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Abstract

Evaluating Inquiry-Based Learning as a Means to Advance Individual Student Achievement. Cherilyn G. Ziemer, 2013: Applied Dissertation, Nova Southeastern University, Abraham S. Fischler School of Education. ERIC Descriptors: Inquiry-Based Learning, Constructivism, Didactic Traditionalism, Pedagogy, Teacher Beliefs

Although inquiry-based learning has been debated throughout the greater educational community and demonstrated with some effect in modern classrooms, little quantitative analysis has been performed to empirically validate sustained benefits. This quantitative study focused on whether inquiry-based pedagogy actually brought about sustained and measurable improved learning and higher levels of student engagement, satisfaction, and understanding. The present study employed classic stratified random sampling to form two sample groups. Sixth-grade student subjects in two middle school science classes completed a four step process: all students completed a 40-question objective pretest, students completed a unit of study in either an inquiry-based learning or a traditional didactic classroom, all students completed a 40-question objective posttest (same as pretest), and all students completed an online post lesson survey to rate personal perception of engagement, understanding, and satisfaction during the unit of study. SPSS statistical software was employed to ensure statistical procedures had been applied appropriately to the NEGD data compiled within the detailed procedures.

The primary researcher disconfirmed Hypothesis 1: given two identically variable-controlled classrooms differing only by pedagogical approach, inquiry-based learning pedagogy would yield statistically significantly superior posttest results as compared to traditional didactic pedagogy. The primary researcher also disconfirmed Hypothesis 2: given two identically

variable-controlled classrooms differing only by pedagogical approach, inquiry-based learning pedagogy would yield statistically significantly superior survey results as compared to traditional didactic pedagogy. The primary research confirmed Hypothesis 3: given two identically variable-controlled classrooms differing only by pedagogical approach, students would manifest a direct, positive correlation between student satisfaction and learning outcomes.

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Table of Contents

Page

Tables

Figures

Chapter 1: Introduction

As early as 1992, the National Science Foundation (NSF) envisioned a learning process driven by discovery and inquiry intended to be in place by the year 2010. The vision was built on the belief the availability of information via the Internet would provide the opportunity for learning situations including synchronous concurrent study and research, as well as providing environments for inquiry and confirmation (NSF, 1992). A key framework of the NSF (1992) vision was based on the availability of new technologies and increasing knowledge in the cognitive sciences, which they believed would influence the development of learning and teaching styles differentiated to each individual.

When the National Committee on Science Education Standards and Assessment (1996) published the new National Science Education Standards, the Committee advocated for innovative teaching and learning focused on inquiry in the process of acquiring information and global perspective. The NSF Directorate for Education and Human Resources, Division of Undergraduate Science, Engineering and Mathematics Education (1996) also recommended an inquiry-based methodology for science, math, engineering, and technology in their report, asserting all students should be allowed to learn relevant subjects by direct experience with the methods and process of inquiry.

Siegel, Borasi, and Fonzi (1998) observed a novel approach to employing inquiry to create the context for the teaching and learning process in mathematics and reading education. Siegel et al. (1998) aligned inquiry-based approach to Dewey (1916, 1933), who described inquiry as a process of removing hesitation or uncertainty in the course of acquiring belief. Further, Siegel et al. (1998) emphasized mathematical inquiry should be employed as a method to begin the process of demystifying the learning of mathematics for students.

Kim, Lee, Merrill, Spector, and van Merrienboer (2008, in Spector, Merrill, van Merrienboer, & Driscoll, 2008) described inquiry-based learning activities as being built on valid problems or situations, thus framing a highly engaging and productive process for student learning. Moreover, Kim et al. (2008) found for a teacher to have an impact on the student's effective learning, the teacher must be willing to demonstrate academic optimism and efficacy, along with a willingness to become a co-learner with assigned students rather than a mere dispenser of information. Accordingly, Luera and Otto (2005) referred to inquiry-based learning as an environment wherein the teacher provided students the opportunity to actively participate in scientific oriented questions and encouraged students to construct a personal knowledge and comprehension. However, in a separate study, Rushton, Lotter, and Singer (2011) found only two percent of science classroom lessons emphasized scientific inquiry as a pedagogical method.

Although inquiry-based learning has been demonstrated to function effectively as a technical pedagogical methodology and taxonomy (Dewey, 1916, 1933; Schwab, 1960), educator beliefs may affect the implementation of inquiry-based learning pedagogy (Harwood, Hansen, & Lotter, 2006). Moreover, during the past four decades, the theory of teacher efficacy evolved to encompass considerable implications affecting a student's learning process (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998; Tschannen-Moran, & Woolfolk Hoy, 2001). The relationship between teacher beliefs and use of inquiry-based learning methods will be discussed in Chapter 2, Literature Review.

Background and Justification

The site for the present study was comprised of two of three sections of sixth-grade science classes at the secondary campus of a private Christian school in southeast Texas. Established in 1974, the school has served upper middle-class residents in the suburban area of northwest Houston, Texas for 39 years. The school's annual report indicated the current enrollment for Grades K-12 is approximately 575 students, with grade six containing approximately 44 students. A review of the data from the school records also indicated the demographic composition of the student population to be 71% Caucasian; 9% African American; 7% Biracial; 6% Hispanic; 2% Asian American; 5% listed as Other (Private School Board, 2013).

In classroom observations performed by the primary researcher at the school site, some educators in the classrooms have continually broadened and improved classroom teaching practices, instructional strategies, and pedagogical knowledge (Dias, Eick, & Brantley-Dias, 2011). Observed, local educators have regularly combined individual experience and knowledge with teaching experience to improve professional self-efficacy, and to transition to constructivist pedagogical methods reflective of inquiry-based learning (Dias et al., 2011). Conversely, the primary researcher has also observed educators at the school site seldom introduced new learning techniques; never attempted to employ new instructional strategies; and, despite ongoing professional training, continued with a classroom pedagogy maintaining a didactic, teacher-centered environment (Dias et al., 2011).

The school administration contributed to the problem of static professional growth by (a) permitting teachers to have a closed-door practice (Gill & Hoffman, 2009), (b) failing to model learner-centered instructional strategies (Bell, Smetana, & Binns, 2005), and (c) failing to implement and sustain a program to encourage and reward teachers who modeled life-long learning (Kagan, 1992a). Key administrators failed to model a professional demeanor thorough personal work efforts and learning habits encouraging teachers to continue in the life-long learning process (DuFour & Eaker, 1998).

Not surprisingly, in the less than optimal environment administrators were reticent to insist on use of inquiry-based learning, in the absence of substantive evidence of effectiveness. The primary researcher, while serving as a mid-level administrator and a member of the staff development team, observed math and science classrooms with teachers: (a) manifesting limited self-efficacy; (b) seldom introducing new learning techniques; (c) never attempting to employ new instructional strategies; (d) continuing with didactic, teacher-centered classroom pedagogy; and (e) specifically resisting use of inquiry-based learning techniques, usually citing lack of evidence of effectiveness (Dias et al., 2011). The present inquiry employed a comparative quantitative experiment in an effort to empirically resolve concern and establish such evidence.

In October 2012, the primary researcher had the opportunity to attend an academic mentoring conference at the University of New Mexico (UNM) in Albuquerque, New Mexico. In a session focused on an NSF-sponsored program designed to assist teachers in developing effective mathematics pedagogy, a veteran university professor with secondary teaching experience argued no empirical findings had yet validated the increased effectiveness of constructivist pedagogies such as inquiry-based learning methods for secondary math students (E. Burroughs, personal communication, October 21, 2012). The presenter further argued in mathematics courses, only sufficiency of the teachers' content knowledge matters for learning outcomes, and the mere existence of a debate between traditional didactic approaches and inquiry-based learning was not a valid basis for adopting non-traditional teaching methods (E. Burroughs, personal communication, October 21, 2012).

The UNM presenter's assertion reflected the current body of knowledge in the education discipline, which indeed lacks a substantial, coherent pool of quantitative research findings specifically pertaining to inquiry-based learning. Although inquiry-based learning has been debated throughout the greater education community, it remains only a few quantitative analyses have been performed to empirically validate its presumed benefits (e.g., Brickman, Gormally, Armstrong, & Hallar, 2009; Harwood, Hansen, & Lotter, 2006). It was interesting to note the research team of Brickman et al. (2009) arrived at the same conclusion as the Harwood et al. (2006) research team from two pedagogically divergent perspectives. Brickman et al. (2009) were recognized for quantitative research which critiqued inquiry-based learning pedagogy, whereas Harwood et al. (2006) were recognized for quantitative findings in support of inquiry-based learning. Yet both research teams concluded there was need for further empirical evidence specifically related to the effectiveness of inquiry-based learning. The primary impetus for the present study was to further inform the comparison between traditional didactic methods and inquiry-based learning to add quantitative evidence to the body of knowledge, which also served as further justification for the present study.

Research Problem

The implementation of inquiry-based pedagogy as recommended by legislated reform guidelines to increase student learning at the local private secondary school had not been quantitatively assessed (NSF, 1992). At the same time, students within the private school had not been adequately improving on mandated achievement indicators as required. The present study focused on whether inquiry-based pedagogy actually brought about measurably improved learning outcomes, and empirically demonstrated advanced individual student achievement.

At the local school site, focused staff development on inquiry-based learning within the subject of science had not occurred. Recently, a science teacher from a private school in west Houston transferred to teach in the science department of the private secondary school serving as the research site for the present study. During the past ten years, the teacher had received extensive training on effective implementation of inquiry-based pedagogy into the science classroom. The primary researcher's professional relationship with the recently transferred teacher afforded a unique opportunity to inform inquiry research in a highly variable-controlled environment.

Deficiencies in the Evidence

As previously discussed and according to a finding by Brickman et al. (2009) which indicated minimal data reflecting authentic changes in pedagogical practices to include inquiry-based learning, signaled a clear need for quantitative research focused on students' learning experience in inquiry-based learning experiences in contrast to didactic learning experiences. Moreover, Kirschner, Sweller, and Clark (2006) promulgated a substantial body of research verified the absence from the body of knowledge of quantifiable findings supporting the effectiveness of constructivist pedagogy, particularly in regard to inquiry-based learning.

The potential contribution of the present study was to address a shortage of quantitative research studies specifically informing effects of changes in pedagogical practices to include inquiry-based learning in a middle school classroom. The primary researcher believed a quantitative study provided the best opportunity to inform the research question, and add incremental empirical evidence to the body of knowledge.

Audience

The present study endeavored to shed light on the effectiveness of inquiry-based learning, while adding insight to the body of knowledge in the field of education. Therefore, the audience for the insight provided by the findings of the present research study will be leaders and faculty members of pre-service education programs, K–12 school administrators, teacher trainers and other academic deans, and in-service classroom teachers.

Researcher's Role

The primary researcher served as a mid-level administrator and a member of the staff development team at the school, and has been responsible for ensuring the school's academic functions excelled and high academic standards were maintained. The primary researcher was qualified to conduct research at the research site because of personal experience as a classroom teacher for twelve years and as a CITI-licensed researcher with two years' experience at Nova Southeastern University. Additional expertise has been gleaned from earning a master's degree in educational technology as well as doctoral coursework in instructional leadership. As a classroom teacher, the primary researcher professionally transitioned from creating a behaviorist classroom environment to framing a constructivist classroom environment. Cumulative classroom teaching has thus provided the primary researcher with direct, practical understanding of inquiry-based pedagogy.

Definition of Terms

Constructivist/constructivism. A learning theory accentuating a process of the individual mind constructing original knowledge (Spector, Merrill, van Merrienboer, & Driscoll, 2008).

Epistemological/epistemology. Focus on the way an individual comes to know (Spector et al., 2008).

Inquiry-based learning. An environment where the teacher provides students the opportunity to engage the learning process by creating personal questions through a process of analysis and reasoning (Luera & Otto, 2005).**Self-efficacy**. An individual's opinion regarding personal ability to create an environment of leading students to engage in the learning process (Tschannen-Moran & Woolfolk Hoy, 2001).

Teacher beliefs. Individual frameworks to give meaning and understanding to a teacher's pedagogy (Luft & Roehrig, 2007).

Purpose of the Study

The purpose of the present quantitative study was to evaluate whether middle school students' learning process and achievement were measurably improved when a teacher employed inquiry-based learning strategies in a private secondary school science classroom in Houston, Texas (Trochim, 2006). Moreover, the primary researcher was responsible for administration of faculty professional development activities. Thus, knowledge gained from the present study would have a direct effect on future professional development programs, and would provide transportable professional development material, which would be valid for use in other secondary schools.

Summary

Inquiry-based learning has been the focus of several key progressive pedagogical initiatives during the past two decades (e.g., NSF, 1992; National Research Council National Committee on Science Education Standards & Assessment, 1996; National Research Council Committee on the Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center for Science, Mathematics, & Engineering Education, 2000; National Research Council Committee on a Conceptual Framework for New K-12 Science Education Standards, Board on Science Education, Division of Behavioral & Social Sciences & Education, 2012). Preliminary research findings and classroom observations generally aligned to create positive impressions and high expectations for inquiry-based learning. However, in an observation also expressed by more cautious researchers, the primary researcher professionally observed implementation of inquiry-based learning was directly affected by administrative orthodoxy and deeply-held teacher beliefs. The present study emanated from the primary researcher's postulate additional empirical evidence of the effectiveness of inquiry-based learning was crucial to (a) overcoming administrator skepticism, (b) overcoming educator cynicism, and (c) removing key barriers to the implementation of inquiry-based learning as standard classroom practice. Moreover, the establishment of new quantifiably measured findings served as a valuable incremental addition to the body of knowledge in the education discipline.

Chapter 2: Literature Review

Rationale

As a science teacher in the early 20th century, Dewey (1916, 1933) recommended inquiry-based learning, strongly advocating students must be active learners in the study of science (Barrow, 2006; Schwab, 1960). Dewey's (1916, 1933) findings aligned with a large corpus of current research which indicated students who depended on themselves to construct personal learning in an inquiry-based learning environment considered the teacher to be a co-learner rather than the primary source of expertise (e.g., Otting, Zwaala, Tempelaarb, & Gijselaersb, 2010; Marshall, 2008). Moreover, such research indicated the student's epistemological beliefs and formation of teaching and learning often seemed to be more highly developed than the beliefs of the teachers (Otting et al., 2010). In light of the intense discussion within the education discipline regarding inquiry-based learning, the literature review focused on the theoretical framework of inquiry-based learning as well as the broader traditionalist versus constructivist debate (Ziemer, 2011b).

According to Matthews (1994), as early as 1958 Joseph Schwab and Jerome Bruner were also early promoters of the inquiry method for teaching and learning (Roby, n.d.). Schwab (1960) asserted the traditional textbook and lecture were insufficient and unsuitable as tools to teach science. As Schwab (1960) reviewed the need for more individuals to be engineers and scientists, Schwab also observed all citizens should understand the analytical work of scientists. Schwab (1960) ultimately asserted all teachers, students, and learning institutions should be involved in inquiry learning. Further, Bruner (1991) introduced Piaget's (1926, 1954) cognitive learning theory to a focus group within the National Academy of Science. The National Academy of Science was in the process of reviewing then-current science curriculum along with classroom teaching and learning practices in science classrooms. Bruner's (1991) efforts were to unite Piaget's (1926, 1954) teachings with inquiry-based learning or as Bruner called the learning process, discovery-learning (Matthews, 1994). Subsequently, Bruner's (1991) writings endorsed and promoted use of discovery learning (Matthews, 1994). However, by 1974 Bruner asserted educational forces had taken discovery learning to the extreme and the process became rigid and orthodox, eliminating the value of the learning experience (Matthews, 1994).

Beyond the technical pedagogical aspect of inquiry-based learning, the teacher played a critical role as a member of the inquiry-based learning framework. The prospect of changing from a familiar pedagogy, in which the teacher was confident and had a positive self-efficacy, to a diametrically opposed pedagogical approach capable of creating feelings of doubt, fear, and negative self-efficacy, was an extremely difficult process for educators (Johnson, 2011). The literature revealed the possibility teacher beliefs and self-efficacy may affect the educator's willingness and ability to transition to a new pedagogy in the educator's learning environment. The primary researcher reflected on (a) the literature, (b) the long-term effects on an educator's beliefs, and pedagogical practices, and (c) resultant potential effects on the educator's students.

Finally, the review of the literature discussed a similar debate surrounding Gardner's (1993, 2006) multiple intelligence theory and the challenge created for educators. Here again, we saw the promise of a new pedagogical concept and the difficulty to realize a new pedagogy in practice (Armstrong, 2000).

Inquiry-Based Learning: The Theoretical Framework

Fundamentally, inquiry-based learning is rooted in two key learning theories. First, Social Learning Theory posited individuals learn by watching other people's actions, approach, and results of the individual's actions or approach (Bandura, 1971, 1977). Bandura asserted individual actions are acquired by the constant watching and scrutinizing of other individuals' actions. Further, Bandura asserted the process of observing the actions empowered a person to develop an understanding of how different behaviors were accomplished and this knowledge functioned as a model for future behaviors. Social Learning Theory clarified personal behavior as a condition of continuous mutual collaboration between cognitive, behavioral, and environmental stimuli (Bandura, 1971, 1977).

Second, constructivist Piaget (1926, 1954) posited the purpose of education was not intended to merely multiply the quantity of knowledge in an individual's possession, but was to create an environment with numerous possibilities and continuous encouragement for the student to conceive of new ideas and discern new knowledge in order to cultivate adults motivated to continue the inventing process (as cited in Hanley-Maxwell & Collet-Klingenberg, 2011; as cited in Whitman, 1980). Piaget asserted each individual begins to build and rebuild a personal framework of reality at birth. In Piaget's view, individuals accomplished the building of a personal framework through interactions with other individuals and objects as mental abilities grow and improve. Piaget strongly asserted the building process was not simply memorizing new information (Hanley-Maxwell & Collet-Klingenberg, 2011).

Educators frequently raise the question of whether inquiry-based learning is an effective process for student learning and cognition. Since 1990, the American Association for the Advancement of Science (AAAS) and the National Research Council National Committee on Science Education Standards & Assessment (1996) have recommended inquiry-based learning for science education (Harwood, Hansen, & Lotter, 2006). The AAAS (1990) and National Research Council National Committee on Science Education Standards & Assessment (1996) asserted students should be involved in learning activities which provided the opportunity for the students to ask and answer useful questions (Harwood et al., 2006). If inquiry-based learning was to succeed, teachers must (a) accept and implement the National Research Council Committee on the Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center for Science, Mathematics and Engineering Education (2000) clarification of inquiry; (b) believe inquiry-based learning was the most effective pedagogical approach to students' learning; and (c) have the personal self-efficacy to believe the individual teacher could successfully teach using inquiry-based methods (Harwood et al., 2006).

Barrow (2006) succinctly framed the problem of science educators developing numerous divergent understandings of the *National Science Education Standards* (NSES) (National Research Council, National Committee on Science Education Standards & Assessments, 1996). The NSES stipulated (a) what science students should understand, (b) the pedagogy educators should employ to clarify science, and (c) the assessment methodologies necessary to determine students' learning (Barrow, 2006). Subsequent to the issuing of the NSES (National Research Council, National Committee on Science Education Standards & Assessments, 1996), confusion arose because teachers' definition of inquiry had developed during the post-Sputnik period science curriculum or from the teacher's undergraduate teacher certification program (Barrow, 2006). In an effort to clarify the essential components of inquiry-based learning, the National Research Council Committee on the Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center for Science, Mathematics, and Engineering Education (2000) issued *Inquiry and the National Science Education Standards: A guide for teaching and learning*.

Based on the clarified definition of inquiry-based learning, the process connected or involved students in a scientifically oriented question (National Research Council Committee on the Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center for Science, Mathematics, & Engineering Education, 2000). Further, the theoretical framework detailed by the National Research Council Committee on a Conceptual Framework for New K-12 Science Education Standards, Board on Science Education, Division of Behavior and Social Sciences and Education (2012) emphasized inquiry-based learning included a variety of mental, social, and physical applications. Moreover, students were personally involved in the learning process instead of merely observing or listening to a teacher. Accordingly, inquiry appealed to the students and gained the students' attention, which enabled true student ownership and interest to develop (Barrow, 2006). Bell, Smetana, and Binns (2005) concurred with Barrow, emphasizing students' abilities to function successfully in an inquiry process were seen on a continuum, as students developed personal inquiry skills over time. Students should be provided with opportunities to develop personal inquiry skills to build to more intricate levels of abilities (Bell et al., 2005). Problematically, Harwood et al. (2006) observed many teachers have failed to comprehend the inquiry-based process or do not have the personal self-efficacy to alter teaching approaches. Therefore, teachers never implemented inquiry-based learning in the classroom learning environment (Harwood et al., 2006).

Fang et al. (2008) studied the effect on inquiry-based learning when specifically incorporating the teaching of reading into the science curriculum for middle school students. In the Fang et al. study, a program organized by the science teacher encouraged students and parents to read books at home on various science topics. Fang et al. observed the reading program deepened (a) the students' base of science knowledge, (b) the students' desire for inquiry learning, and (c) nurtured the students' desire to read. Further, they found students' abilities to identify problems and develop possible solutions improved (Fang et al., 2008).

Dias, Eick, and Brantley-Dias (2011) described the experience of a science teacher who returned to the classroom after a ten-year absence, and employed an inquiry-based, student-driven approach to the learning process. The teacher determined inquiry-based methodology was successful, but also ascertained a need for a variety of approaches in employing inquiry in order to maintain student attention and engagement. Rushton, Lotter, and Singer (2011) reported on a study focused on providing professional development with the goal of changing teachers' beliefs about inquiry-based learning. The professional development sessions provided the framework to motivate the teachers to accept and implement a personal pedagogy of inquiry-based learning. During the sessions teachers (a) practiced the development of inquiry-based lessons, (b) presented lessons to peers, and (c) reflected on the process. The three components contributed to the change in teachers' beliefs and implementation of inquiry-based learning (Rushton et al., 2011; Ziemer, 2011a).

In a research project conducted by Benzviassaraf (2011), inquiry-based learning was employed in a study about the water cycle. The conclusions drawn from the study illuminated the process of students developing systemic mind maps and recalling the information based on personal learning processes, which remained stable as students grow older (Benzviassaraf, 2011). The study also emphasized the need for educators to provide an environment where students' learning experiences connected the meta-cognitive learning patterns in order for students to construct personal models as part of the ongoing learning process (Benzviassaraf, 2011).

The Illinois Math and Science Academy (IMSA) promoted a program for children from low-income neighborhoods focused on engaging students at an early age in inquiry-based learning and problem-based learning situations promoting mathematical and scientific reasoning (Marshall, McGee, McLaren, & Veal, 2011). The program stressed inquiry-based learning and was basis for the design of the students' learning experiences. The specific approaches were apparent in the program when Marshall et al. reviewed students' learning opportunities. The environment provided the opportunity for students to accept personal responsibility and to ensure the success of the learning process (Marshall et al., 2011). The IMSA program also allowed the students to become cognitive learners and employed the students' personal abilities and creativity. The IMSA students inculcated the process of being responsible for the depth of individual thought processes and shifted from the role of a passive learner to actively generating and constructing personal knowledge. An added benefit of the IMSA program for the students was the development of a positive worldview because the students now understood and appreciated personal cognitive abilities and creative thinking (Marshall et al., 2011).

While conducting observations of middle school teachers, Marshall and Horton (2009) noted the multitude of models of inquiry-based learning pedagogy, and the consistent components necessary in the models to ensure effective inquiry-based learning pedagogy. First, a student experienced disconcerted feelings, which compelled the student to build upon prior experiences, information, and comprehension (Piaget, 1926, 1954; Marshall & Horton, 2009). Second, Vygotsky's (1978) zone of proximal development was employed to emphasize the significance of scaffolding learning and this enabled the student to think critically and complete an effective inquiry process (Marshall & Horton, 2009). Third, an essential component of the inquiry learning classroom was to provide differentiated instruction in order for students to have the opportunity to actively construct personal knowledge and learning as a result of critical and analytical thinking (Marshall & Horton, 2009; Marshall, Horton, Igo, & Switzer, 2009). Moreover, inquiry-based learning models focused on students' construction of a more intense and profound understanding as opposed to didactic models which focused on mere memorization of facts. Ultimately, inquiry-based learning assisted students in the personal development of a more intense interpretation of the concept studied (Marshall & Horton, 2009; Marshall, Horton, Igo, & Switzer, 2009).

Further, Marshall and Horton (2009) asserted the sequence of the teacher's instruction directly affected the level of cognition employed by students. If the teacher provided time for students to explore concepts before the presentation of an explanation, the students' thought processes were more intense and deeper. However, the time for exploration was not unguided time, but rather time where the teacher established the boundaries and concepts to be explored (Marshall & Horton, 2009). When teachers allowed an increased amount of time for students to explore core concepts, the students' cognition was significantly more intense. Conversely, when teachers focused on a didactic explanation of core concepts, the students' cognition decreased (Marshall & Horton, 2009).

Moreover, Horton, Marshall and White (2009) asserted the standards for inquiry-based learning should focus on significant factors. Further, Horton et al. (2009) argued the time spent on inquiry-based learning was superior to time spent in other pedagogical frameworks and employed authentic assessments to determine if the students' learning reached the targeted standards.

Consequently, Marshall, Smart, and Horton (2009) realized the necessity for a tool to reinforce the teachers' transition to inquiry-based pedagogy and to assess the quantity and quality of inquiry-based instruction. The realization by Marshall et al. resulted in the creation of the Electronic Quality of Inquiry Protocol (EQUIP). EQUIP provided a context for teachers to become more deliberate and purposeful with their instructional strategies as they attempted to improve the extent and value of personal inquiry-based pedagogy (Marshall et al., 2009). The explanations and levels of measurement within the context of the EQUIP tool provided targets which allowed the teachers to consider ways to continually improve inquiry-based learning (Marshall, Horton, & White, 2009). Moreover, EQUIP provided administrators a tool which was employed in teacher observations and assisted in the evaluation of the quality of the inquiry which occurred in the classroom (Marshall, Horton, & Smart, 2009; Marshall, Horton, & White, 2009; Marshall, Smart, & Horton (2009).

Based upon the EQUIP framework, Marshall, Smart and Horton (2011) conducted a study focused on enhancing the quality of inquiry-based learning instruction with the creation of a yearlong professional development program. The program involved training teachers on the major components of inquiry, including engage, explore, explain, and extend, with formative assessment and student reflection incorporated into the major components (Marshall et al., 2011). During the yearlong program, numerous observations were conducted employing the EQUIP analysis tool (Marshall et al., 2011). EQUIP provided the framework to evaluate the teachers on 19 significant points and the teacher's ability to link inquiry-based learning to instruction, curriculum, discourse, and assessment (Marshall et al., 2011). The data obtained from the observations and the teachers' self-assessment indicated significant growth in the teachers' instructional strategies and skills for inquiry-based learning (Marshall et al., 2011). However, the data indicated teachers had difficulty altering personal assessment beliefs and procedures to integrate into inquiry-based learning practices (Marshall et al., 2011). Marshal et al. asserted the implications of the study illuminated the teachers' abilities to alter personal instructional practices and strategies, but also framed the difficulty incurred as teachers attempted to assess the inquiry-based learning process of the students.

Subsequently, Marshall, Smart, Lotter, and Sirbu (2011) conducted an analysis of two inquiry observation tools in an attempt to determine whether the actual quality of inquiry-based instruction is measurable. The analysis reviewed two tools employed as observational measurement tools: EQUIP and the Reformed Teacher Observation Protocol (RTOP) which focused on dependability, consistency, validity, and effectiveness in relation to inquiry-based instruction (Marshall et al., 2011). Marshall et al., found the EQUIP and RTOP instruments were dependable and consistent, and were effective methods to evaluate inquiry-based instruction. However, EQUIP exceeded the RTOP in the measurement of inquiry-based instruction, while RTOP was superior when evaluating for broader constructivist instructional strategies (Marshall et al., 2011). Additionally, because EQUIP employed a rubric with descriptions of each level of inquiry-based instruction teachers received timely feedback from the instructional observation (Marshall et al., 2011).

Finally, Stripling (2003, 2008, 2009a, 2009b) defined inquiry-based learning as a method of learning driven by a problem and an analytical thought process. Knowledge and skills acquired from the inquiry-based learning process were typically long-term and more comprehensive when compared to knowledge acquired from textbooks and memorization processes (Stripling, 2003, 2008, 2009a, 2009b). Stripling's Model of Inquiry detailed a process flowing through six stages. The six stages may be repeated and students are encouraged to continually (a) redirect personal thoughts to the learning, (b) the application of new knowledge, (c) the development of new questions or hypotheses, and (d) the development of new information to answer questions and test personal hypotheses. Stripling encouraged educators to employ primary sources because educators naturally involve students in the inquiry process when primary sources are used. Students become involved in a progression of (a) critical thinking, (b) compare and contrast, (c) understanding of various perspectives, (d) deductive reasoning, and (d) synthesizing information (Stripling, 2003, 2008, 2009a, 2009b). A graphic illustration of the Stripling Model of Inquiry is provided in Figure 1.

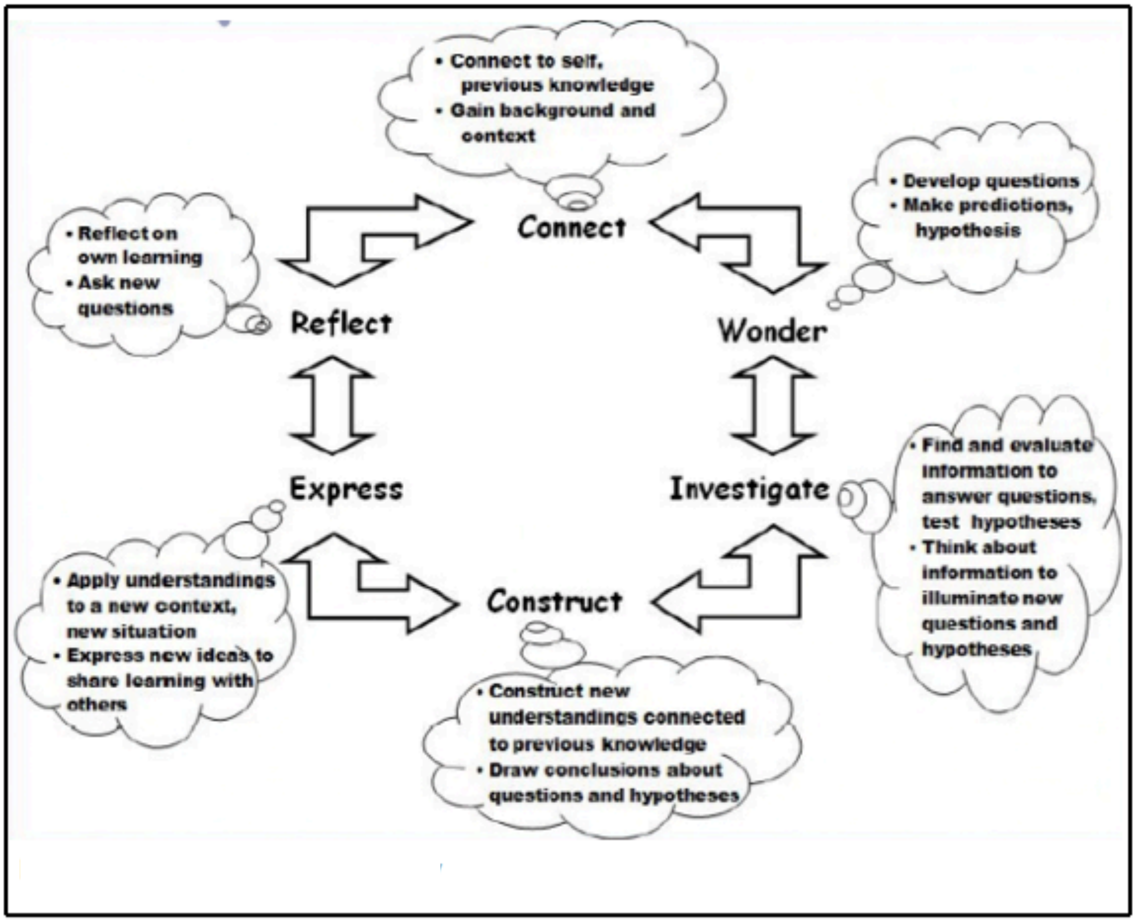

Figure 1. Stripling Model of Inquiry. Adapted from "Teaching Inquiry with Primary Sources," by B. K. Stripling, 2009, *Teaching with Primary Sources Quarterly*, *2*, p. 2. Reprinted with permission.

The studies and programs described above illustrate the complex relationship between learning theories and pedagogical practice in the implementation of inquiry-based learning. Although the fundamental theories of social learning, constructivism, and constructionism were well understood (Bandura, 1971, 1977; Piaget, 1926, 1954; Papert, 1993; Papert & Solomon, 1971), the actualization in classroom teaching has been quite elusive. The realization of the difficulty of actualization in the classroom framed the challenge of urging inquiry-based learning toward well-defined practice sets.

The Traditionalist vs. Constructivist Debate

Disagreements within the education community focused on traditionalist vs. constructivist pedagogy have erupted for decades. Traditionalists' pedagogy was frequently labeled as the official pedagogy and constructivists' pedagogy was referred to as classic pedagogy (Smith, 1998). Dewey (1916, 1933) asserted the goal of teaching science to students was to provide the student with an approach to learning focused on development of a scientific perspective and thought process. For students to successfully develop a scientific perspective and thought process, Dewey argued students must complete a process of constructing personal knowledge by developing beliefs created in an inquiry process.

From another perspective, Edward Thorndike decried the mechanical, assembly line approach to education termed Fordism (Gibboney, 2006). Thorndike focused on individual subject areas for transfer of learning, and developed a philosophy of the effect on an individual's intelligence was equal whether studying Latin or a skill-based class like cooking or wood shop (Gibboney, 2006). Thorndike also asserted non-educator specialists should decide (a) concepts to be taught, (b) how the concepts were to be taught, and (c) appropriate assessment of the concepts (Gibboney, 2006). Due to Thorndike's absolute belief in numerical and statistical analysis, Thorndike believed the non-educator measurement specialists were empowered to determine the standards, goals, and assessment tools for education based on the results of previous assessments (Gibboney, 2006).

Gibboney (2006) observed constructivists believe Thorndike's influence on education in the United States framed the basic philosophy for reforms during the last quarter of the 20th century and early in the 21st century. For example, the No Child Left Behind Act (2002) required 100% of students to reach an acceptable skill level by 2014 (Gibboney, 2006). The skill level referred to in the No Child Left Behind Act (2002) was assessed by a numerical test score which ignored any consideration of environment or economic level of the individual child (Gibboney, 2006). Gibboney concluded Dewey's (1916, 1933) philosophy of education was based on the human ability to think, whereas Thorndike's philosophy of education was based on a mechanical assembly line approach.

Pogrow (2006) asserted the debate between traditional and constructivists should seek a compromise of the two because neither was theoretically correct for the development of an effective educational system. Traditionalists believed education should be based on a predictable system, easily influenced, linear, uncreative, and unimaginative. In contrast, the constructivists believed all children learned when (a) the environment was student-centered, (b) instruction was individualized, and (c) the children freely employed a framework provided for construction of personal learning (Pogrow, 2006). Pogrow argued educators must combine the finest traits of both traditionalist and constructivist to improve U.S. schools and build stable and sensible learning environments.

Elmore (2012) reflected on the traditionalist instructional perspective when he reported many creative geniuses disliked the instructional process experienced in school. Thomas Edison (1847-1931) asserted a personal blessing was the deficiency in prescribed education (Elmore, 2012). Edison is known to have concluded if required as a child to participate in formal education, the teachers' methodology and perspective would have affected Edison's personal inclination to create and invent (Elmore, 2012). Further, Albert Einstein's (1879-1955) recollection of required education was to conclude education was an unpleasant experience (Elmore, 2012). Einstein contemplated later in life about what he believed to be the near miracle formal education had not completely stifled the individual's sense of interest and inquiry, which he believed was essential to life (Elmore, 2012).

Moreover, Marshall (2008) asserted professional development sessions for equipping educators with constructivist pedagogy should not become rote or a system administered as a step-by-step process. Rather, learning experiences should be tailored to the individual educator and classroom in order to build meaningful, substantial classroom processes and provide long-term benefits to the student (Marshall, 2008). Tailored sessions will enable educators to (a) focus on understanding constructivist learning methodologies, (b) eliminate laborious didactic lesson explanations, and (c) include more opportunities for student critical-thinking and collaboration in the learning process (Marshall, 2008). In a tailored environment, assessments will become authentic and students will frequently reflect on the process and perform self-assessments of the personal learning process (Marshall, 2008).

On the other hand, Pine and Aschbacher (2006) evaluated the effectiveness of employing inquiry-based learning science curriculum with fifth-grade students. Despite the belief among reformers of a benefit from the objectives for K–12 students to develop personal skills and abilities to conduct scientific inquiries promulgated in the National Science Education Standards (National Research Council, National Committee on Science Education Standards and Assessment, Board on Science Education, Division of Behavioral and Social Sciences and Education, 1996), Pine and Aschbacher's study found the reformers' beliefs were not always true. The Pine and Aschbacher's study revealed no significant differences in student learning between hands-on inquiry classrooms and learning in textbook classes. Results of Pine and Aschbacher's study indicated when the teacher instructions and guidance were weak and ineffective, students were required to depend on personal abilities to scaffold prior knowledge and basic intelligence to construct new knowledge. Consequently, the students' did not achieve a thorough understanding of the information (Pine & Aschbacher, 2006). Pine and Aschbacher therefore recommended schools support teachers' professional development in (a) the area of science, (b) the components of inquiry-based learning, and (c) pedagogical knowledge to facilitate movement of the teachers beyond the shallow and artificial instruction which occurred in science classes.

Kirschner et al. (2006) also fervently criticized unstructured constructivist pedagogy in which educators were encouraged to employ teaching processes with a limited amount of direct instruction and allow students to meander aimlessly while working on projects or creating knowledge independently. Instead, Kirschner et al. believed an effective pedagogy for educators included (a) the didactic presentation of information, (b) a thorough explanation of the ideas, (c) a structured framework to enable students to learn, and (d) attention to students' cognitive thought processes (Kirschner et al., 2006). Moreover, the perspective of Kirschner et al. was grounded in research indicating individual cognitive abilities required guided instruction and accordingly, instruction which lacked specific teacher guidance was ineffective. Clearly, the debate continues, which provided a key impetus for the present study.

Similar Problem: The Multiple Intelligence Conundrum

Gardner's (1993, 2006) theory of Multiple Intelligences (MI) created a similar debate in the education community to the didactic vs. inquiry-based learning debate. Specifically, although MI had proven to be an engaging concept which interested and excited many educators, MI had also proven to be difficult and enigmatic to implement in real-world classroom practice (Klein, 1997; Shore, 2004). Lambert et al. (1995) observed MI strengthened the constructivist learning theory because of the relationship between the student's involvement in constructing personal knowledge and active learning. Conversely, Klein (1997) questioned whether MI was the correct type of theory for education because of the breadth of the cognitive processes and the difficulty of addressing any educational learning process with validity and reliability.

The major result of the difficulty of implementing MI was while a large corpus of research material had suggested promise in illuminating teaching practices (e.g., Gardner, 1993, 2006; Armstrong, 2000), more than two decades after Gardner posited the MI theory, many teachers were reticent to attempt MI-based lesson construction. Teachers' reticence results from not fully understanding and appreciating the potential of the theory to better understand students (Klein, 1997; Frankman, 2000). Thus, in many cases teachers continued to use traditional single-intelligence teaching methods even after receiving substantial MI training, because clear links between the theory and the application in daily practice were not well-defined by the education research community (Klein, 1997; Frankman, 2000).

Gardner's (1993, 2006) MI theory emphasized three key elements: (a) pedagogy should focus on the individual student's ability to learn and have individualized assessment, (b) communication of educational goals should be clear and concise, and (c) the benefit of employing multiple tools and methods to learn significant concepts should be emphasized in teacher training. Klein (1997) noted MI had successfully stimulated a variety of classroom techniques focused on students' learning preferences. However, Klein also noted teachers' observations of the broadness of the theory, and the resulting difficulty curriculum developers experienced integrating MI in a beneficial manner. Moreover, Klein asserted the MI theory is designed around a concept assuming students' abilities are unchanging, and the concept has shown to be untrue. Accordingly, additional research on methods students employed to construct personal knowledge may be more applicable to actual teacher pedagogical practices than the MI theory (Klein, 1997).

Shore (2004) promulgated the MI theory provided educators the opportunity to collaborate in the development of practices focused on the engagement of students in various methods employed to learn. Moreover, Shore advocated the MI theory should be included when developing professional development opportunities for educators in order for the educators to experience the MI theory in a personal learning process. Shore asserted once educators participated in a positive personal learning experience with the MI theory, the educators employed the MI theory in the learning process of students.

Similar to the theory and purpose of inquiry-based learning, one of Gardner's (1993, 2006) primary goals was to assist educators in viewing students and the classroom from a variety of different perspectives instead of one consistent perspective. Gardner also encouraged educators to be receptive to the need to adjust personal pedagogical approach in order to assist students in the learning process. Gardner insisted educators should shift from a didactic, teacher-centered classroom to an environment in which teachers were co-learners with students and professional peers.

Effects of Teacher Beliefs on implementation of Inquiry-Based Learning

Clearly, implementation of any pedagogical system must contemplate the critical role of the teacher, and therefore must also consider the teacher's conceptual framework. Regarding teacher beliefs about the cognitive process, Saettler (2004) found by the 1980s the behaviorist model of processing information had been replaced with theory of cognitive learning in education. Research focused on cognition, illuminating the pedagogical practice of (a) including instructional activities, (b) providing opportunity for the learner to actively construct verbal and mental processes, and (c) relating the processes to memories and knowledge as a significant component of the learning process (Saettler, 2004). During the 1980s, research concentrated on diverse instructional environments. Saettler observed teachers' beliefs and optimism regarding students' abilities in verbal communication skills, reading, and writing directly affected content the teacher resolved to teach the students.

Brownlee, Schraw, and Berthelsen (2011) asserted the process of a teacher growing to a point of recognizing the effect their personal beliefs are having on students' learning process has the potential to be very beneficial when the ultimate goal is to improve the teacher's practice (Wagner, 2013). The process of reflecting on individual beliefs urges the educator toward an honest perspective on personal instructional strategies, and may eliminate conflicts with supervisors, students, and parents (Brownlee et al., 2011). The reflexive process affords teachers the ability to comprehend the development of personal instructional strategies and perceptions of ideal classroom practices, as well as provides the opportunity to realize change could improve personal practices (Brownlee et al., 2011; Wagner, 2013).

Kagan (1990) defined teacher cognition as teachers' personal reflections on (a) beliefs, (b) knowledge of pedagogy, (c) knowledge about the students, (d) content knowledge, and (e) awareness of personal classroom management strategies and skills (Brownlee et al., 2011). Kagan (1992a) also observed during the 1980s, researchers began conducting studies focused on the processing of information, beliefs, and the intellectual progression inspiring the teachers' daily actions in the classroom. The research studies asserted every teacher had a distinctive organic system of classroom environmental beliefs and routines are permanently entrenched in the teacher's individual behavior and previous life experiences (Kagan 1990, 1992a; 1993). Subsequently, Kagan (1992b) pointed out the difficulty in accurately measuring the teacher's inherent beliefs. Kagan (1992a) asserted a teacher's professional processes should be more realistically regarded as beliefs, because teaching had typically been described by teachers who generally manifested an absence of empirical truths or precise answers to significant pedagogical matters (Apedoe & Reeves, 2006; Kagan, 1992a).

Cohen (1991) posited teachers' pedagogical methodologies grow from a personal love for the subjects and not from an effort to relate learning theories or principles learned in a preservice education program. Cohen also asserted teaching methods were natural phenomena developed from a person's approach and concern with realizing personal potential more than the student realizing personal potential (Kagan, 1992a).

The primary researcher's experience had been if a teacher did not love the subject they were teaching, but were merely teaching rote, uninspired curriculum and content, the classroom would be a joyless, uninspired learning environment (Arbaugh et al., 2008). The cognitive constructivist teacher modeled a visual self-image of a joyful co-learner with the students and personally benefitted from the learning process in the classroom (Quigley, Marshall, Deaton, Cook, & Padilla, 2011). Student satisfaction and the desire to learn were a direct response to the teacher's joy, which were a function of authentic co-learning. When the teacher created an orthodox, joyless framework for the learning environment, there was an absence of gratification for both the teacher and the student. In such a situation, the learning process failed (Quigley et al., 2011). Orton (1996) asserted an important component of the teachers' beliefs focused on continued development and a practical quality in regard to students. The teacher created a constructivist learning environment wherein the students were encouraged to expand their knowledge with the teacher as a co-learner with them. However, Orton warned teacher beliefs (a) were rooted in context, (b) were typically unspoken, and (c) were difficult to alter. Teachers were encouraged to be involved in a mutually reflective process where personal beliefs were discussed and everyone focused on the resolution of some of the issues in the classroom (Orton, 1996).

At the 2011 Association for Supervision and Curriculum Development (ASCD) annual conference, education researcher Robyn Jackson (2011) asserted teachers' expectations were not based on the student's abilities, but were instead based on the teacher's core beliefs and ideals brought to the classroom (Varlas, 2011). Jackson stressed the importance of teachers being sensible when considering classroom circumstances and being honest about how core beliefs and ideals or values affected personal practice. Expectations developed from a blending of a teacher's values and beliefs. In order to raise the expectations of either values or beliefs, both must be improved (Jackson, 2011; Varlas, 2011).

Jackson (2011) therefore asserted for an individual teacher to raise personal values, a shift in personal investment from failed ideas and strategies to diverse ideas and strategies dissimilar to ones previously employed occurred. Jackson encouraged teachers to elevate personal beliefs by changing personal experiences and utilization of a different approach as well as observations of students in new and various situations. Different experiences and observations provided the opportunity for the teacher to develop new beliefs about students and the students' abilities (Jackson, 2011). Having the ability to realistically evaluate the situation and individual beliefs enabled the teacher to develop the pedagogical skills to make the prospect of raising expectations possible (Jackson, 2011; Varlas, 2011). In Jackson and Varlas' view, the skilled teacher would convince a student who had little or no self-efficacy to believe in the teacher who was committed to the co-learning process.

For decades, Gill and Hoffman (2009) focused on researchers' intent on studying the factors contributing to teachers' pedagogical choices. However, Feldon (2007) alleged the majority of the studies depended on teacher self-reports because of two basic theories in regard to teachers' cognition: (a) teachers' planned behaviors are cogent relative to personal knowledge or experience in specific classroom situations; and (b) teachers are human beings, not machines, which illuminated the need for research to determine how teachers made decisions (Feldon, 2007). Feldon (2007) and Gregoire (2003) jointly proposed a theory of teachers' cognition involving two processes (Gill & Hoffman, 2009). The dual-process model offered a more regimented path of cognitive processing and working in tandem with routine mental patterns, pointed to the conclusion the majority of teachers' decisions were automatic (Gill & Hoffman, 2009). The decision making process was posited to be motivated by beliefs about students, learning, instruction, and subject matter resulting from personal teaching and learning experiences during the K-12 school experience (Nuthall, 2005). The dual-process model also incorporated the concept teachers' beliefs were not actually exhibited or practiced in the classroom with students (Gill & Hoffman, 2009). Additionally, the dual-process model implied implicit beliefs were comparable to habitual choices and complied with rules as a prompted response focused on goals or results (Bargh & Ferguson, 2000; Gill & Hoffman, 2009).

In a discussion regarding reform in education, Fullan (2010) asserted teachers changed personal pedagogical strategies based upon personal experiences and the results observed in students. Teachers were not convinced about a new strategy because someone lectures them or because someone presents evidence from another teacher's classroom (Fullan, 2010). The catalyst for teacher pedagogical change was authentic personal experiences to assist in the transformation (Fullan, 2010).

Stigler & Hiebert (1999) conducted a video study of typical classrooms in Japan, Germany, and the United States as part of the Third International Mathematics and Science

Study (Nuthall, 2005). A conclusion of the study was teaching, as typically carried out in classrooms, was a traditional custom (Nuthall, 2005; Stigler & Hiebert, 1999). Further, although teachers frequently believed in cognitive-constructivist education, the teachers were often actually behaviorist educators and believed knowledge must be provided and distributed instead of having an environment offering students the opportunity to construct personal knowledge (Nuthall, 2005; Stigler & Hiebert, 1999). Brownlee (2004) therefore asserted constructivist teaching strategies were based in curriculum which provided support and sustained the constructivist learning process and were analogous to the framework of the course. The constructivist curriculum and teaching approach led the students in the development of higher-order learning and development of intrinsic beliefs (Brownlee, 2004).

Nuthall (2005) asserted despite the current emphasis on changing teacher education programs and transforming teaching practices, the essence of the ritual of teaching remains static, maintained by an unchanging framework of beliefs and suppositions native to the principles of education. Nuthall posited a need for researchers to focus on the construction of a theory based on valid evidence to explain factors guiding teachers as routine decisions are executed, and the development of a compelling foundation for teachers to learn from personal ritualized classroom practices. Only when teachers have recognized and comprehended the effect personal teacher beliefs and actions have on students' learning process does the teacher have the ability to ensure students achieve a successful learning experience, despite personal capabilities and ethnic context (Nuthall, 2005).

Moreover, Nuthall (2004) found despite research studies identifying distinguishing characteristics typically exhibited by an effective teacher, a reliable method to assess the effect of the teacher characteristics on student learning was not available. Additionally, Nuthall asserted the impossibility of knowing whether the teacher beliefs and characteristics were truly related to student learning. Consequently, he speculated the development of a research-based explanation of teacher characteristics essential in the daily classroom decision-making process and simultaneously enhancing the student learning process appeared to be a remote possibility (Nuthall, 2004). Nuthall concluded with an assertion regarding the necessity for teachers to comprehend the underlying principles of how personal beliefs and actions affected students' cognitive learning process in order to guarantee effective student learning.

As Dever and Hobbs (2011) asserted, if teachers are to succeed in changing personal beliefs, teachers must first confront personal beliefs. The historical context of teachers' school experience which shaped personal beliefs and visions had to be analyzed and the existing belief structure had to be challenged (Deaver & Hobbs, 2011). Change in the teachers' beliefs did not occur until teachers completed a reflective process and analyzed the conflict between personal beliefs and practice. The personal examination by the teacher drove the entire process to change (Deaver & Hobbs, 2011). In a two-year case study, Johnson (2011) investigated the difficulty of teachers successfully changing personal pedagogy to enable all students to succeed. Johnson observed focused, rigorous professional development sessions enabled educators to alter personal pedagogy. Luera and Otto (2005) also observed the difficulty of science teachers transitioning personal pedagogy to inquiry-based learning. Rushton, Lotter, and Singer (2011) investigated how beliefs and actual classroom behavior were affected when teachers were involved in an intensive yearlong professional development program with frequent observations which employed the RTOP. Rushton, Lotter, and Singer found the RTOP to be effective.

Regarding intrinsic teacher beliefs, Goddard, Hoy, and Woolfolk Hoy (2000, 2004) asked whether the teachers' academic optimism and efficacy affected personal beliefs about the learning process. Goddard, Hoy, and Woolfolk Hoy pointed out the Social Cognitive Theory posited by Bandura (1971, 1977) asserted student and teacher efficacy were essentially personal opinions regarding personal ability to systematize and implement the actions necessary to generate an expected result in certain environments.

Accordingly, Beard, Hoy, and Woolfolk Hoy (2010) focused a recent study on testing the hypothesis of individual academic optimism being composed of (a) the teacher's personal efficacy, (b) the teacher's confidence in parents and students, and (c) the teacher's pedagogical priorities. Beard et al. asserted academic optimism included intellectual, emotional, and social abilities combining to become one cohesive belief. Consequently, efficacy was defined as a belief and a cognitive function (Beard et al., 2010; Woolfolk Hoy, Hoy, & Kurz, 2008). Therefore, four societal circumstances were necessary in schools to support student achievement and learning: (a) teachers who believed in personal teaching skill to enable the students to succeed; (b) parents who were deeply involved and supported school programs; (c) teacher-led community of learners who cooperatively implemented student-centered instructional strategies to improve student learning; and (c) an environment of high expectations from the students' efforts established by the school, faculty, and parents (Beard et al., 2010). The concept of academic optimism composed of efficacy, trust, and academic emphasis promoted such an environment (Beard et al., 2010). The optimistic belief the students can succeed was epitomized in teachers' sense of efficacy (Beard et al., 2010).

Beard et al. (2010) asserted a variety of factors are involved in accounting for student academic achievement beyond personal economic situation, and a school's collective teacher efficacy was one such factor. A second factor was the individual teacher's belief in the student's ability to succeed in academic endeavors. Woolfolk Hoy et al. (2008) and Beard et al.

emphasized the teacher's belief was a personal conviction regarding personal ability to engage students, and develop working relationships with parents and students, while accomplishing academic tasks. The teacher's determination to succeed with the students became stronger because of life experiences, and enabled the teacher to assist students who experienced difficulty accomplishing the learning process (Beard et al., 2010). Through the process of assimilating the teacher's personal experiences, the development of the teachers' beliefs motivated pedagogical practice (Beard et al., 2010).

Magno and Sembrano (2007) conducted a study focused on the relationship of teacher behavioral variables using Structural Equations Modeling (*SEM*). The first model reviewed the effect of the teacher's behavior characteristics and efficacy on personal performance. In the second model, the impact of learner-centered practices on the teacher's behavior, effective teaching and efficacy were studied. The study determined teachers who employed learner-centered pedagogical practices also employed personal self-efficacy to increase personal effectiveness (Magno & Sembrano, 2007).

Beard et al. (2010) emphasized the need for a dependable and effective method to measure a teacher's belief in enabling students to successfully accomplish the learning process. Further research focused on identifying individuals and schools who currently exhibited various levels of positive beliefs, and the contributing factors of the development and exhibition of positive beliefs would contribute to the development of an effective measurement (Beard et al., 2010). Knowledge of the contributing factors in the development of positive beliefs would assist teachers and administrators who desired to understand the required circumstances to develop teachers with a personal positive belief in the educational process (Beard et al, 2010).

Taken as a whole, the body of knowledge illuminated teacher beliefs from three perspectives:

1. We found the teacher's beliefs about the cognitive process are based on a lifetime of individual behavior and experiences. However, as Kagan (1992a) asserted, it was extremely difficult to determine the teacher's inherent beliefs, because teachers' teaching styles developed because of a love for the subject and concern with a personal portrayal of competency rather than the student's competency. Teachers reflected on the beliefs and values personally brought to the classroom and critically examined the beliefs and values in an effort to improve the learning environment and to be a co-learner with the students (Kagan, 1992a).

2. The review clarified the primary researcher's understanding the success of inquiry-based learning was dependent on the teachers' beliefs about the learning process (Beard et al., 2010). In addition, inquiry-based learning methods required a variety of approaches to maintain student engagement and consistent reflection on the process by the teacher (Dias, Eick, & Brantley-Dias, 2011). Teachers provided a learning environment where students' learning connected with the meta-cognitive process and students accepted a personal responsibility for learning (Benzviassaraf, 2011). A key component for successful inquiry-based learning was the adherence to the assertion which emphasized inquiry learning activities was built on valid and realistic problems or conditions (Kim, Lee, Merrill, Spector, & van Merrienboer, 2008; in Spector, Merrill, van Merrienboer, & Driscoll, 2008). The key component framed a highly engaging and successful process for student learning (Kim et al., 2008). Moreover, teachers were willing to demonstrate academic optimism and efficacy, along with a willingness to become co-learners with students rather than mere dispensers of information (Kim et al., 2008).

3. In reviewing the literature about teachers' academic optimism and efficacy it was asserted both factors had a tremendous effect on the students' achievement and learning process (Beard et al., 2010; Goddard et al., 2000, 2004). However, there was a continuing need for research related to academic optimism and efficacy in order to ascertain the contributing factors to develop academic optimism and efficacy (Beard et al., 2010). The gestalt of the three perspectives became the teacher's classroom presence, and the critical behavioral impetus for implementation of new or different pedagogical practices (Beard et al., 2010).

Moreover, Haberman (2011) posited the strength of teachers' beliefs and personal determination to implement the beliefs affected (a) teacher's willingness to inculcate professional development, (b) willingness to being a life-long learner, and (c) willingness to enhance long-term effectiveness in the classroom. Accordingly, the primary researcher became increasingly convinced the power of teacher beliefs was the key to unlocking the teacher's self-efficacy and creative gifts (Beard et al., 2010; Woolfolk et al., 2008). In the course of many classroom observations at both the elementary and secondary levels, it was broadly apparent for the teacher to express joy, the teacher must feel empowered; and for the teacher to feel empowered there must be a convergence of a strong belief system and a well-founded sense of efficacy. The primary researcher's formative conviction appeared to be well supported by the present review of the literature.

Current Theory and Practice: The Need for Additional Quantitative Findings

As previously discussed and in light of the finding by Brickman et al. (2009) finding there had been minimal empirical data reflecting authentic changes in pedagogical practices to include inquiry-based learning, there was clearly a need for additional quantitative research focused on students' learning experience in inquiry-based learning experiences in contrast to didactic learning experiences. Additionally, as inquiry-based learning was more rigorously researched, Brickman et al. emphasized the necessity of assisting students' transition from a role of receiver of knowledge to being a creator of knowledge. In other words, inquiry-based learning research must drive inquiry-based learning practice (Brickman et al., 2009).

Moreover, Kirschner et al. (2006) promulgated a substantial body of research verifying the absence from the body of knowledge of quantifiable findings supporting the effectiveness of constructivist pedagogy, particularly in regard to inquiry-based learning. Kirschner et al. spoke fervently against constructivist pedagogy, which they believed encouraged educators to employ teaching processes with a limited amount of direct instruction, and allowed students to meander aimlessly as they developed projects or personal knowledge. Mayer (2004) also expressed concern related to the constructivist pedagogy and questioned the long-term effects of constructivism on education and, specifically, whether inquiry methods have a negative effect on students' education and learning processes. Subsequently, Clark, Kirschner, and Sweller (2012) reiterated the lack of research confirming teaching with limited guidance was an effective method to facilitate student learning other than with the most skilled students. Rather, research evidence confirmed teachers should provide complete and direct instructional guidance for beginning to intermediate learners to ensure an effective learning process instead of allowing students to determine the significant information to learn (Clark et al., 2012).

However, the process of accomplishing effective implementation of inquiry-based learning has been problematic depending upon the circumstances and environment (Phillips, Berg, Rodriguez, and Morgan, 2010). Phillips et al. conducted research employing the methodology of participatory action research in a middle school program designed to assist students behind grade level in a course recovery process. In a learning environment controlled and strictly maintained by adults, Phillips et al. observed the success of inquiry-based learning was affected by the teachers' beliefs. When the teacher believed the students would benefit from the inquiry-based learning process, the teacher facilitated the inquiry for the students and supported the learning process (Phillips et al, 2010). However, if the teachers had limited understanding of the inquiry-based learning process and believed the students would not benefit from the process, the teacher maintained a didactic structure, which obstructed the students' inquiry-based learning process (Phillips et al., 2010).

In addition to the possibility a teacher could obstruct the success of an inquiry-based learning process, Friedman et al. (2010) expressed concerns regarding inquiry-based learning. The National Research Council Committee on the Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center for Science, Mathematics, and Engineering Education (2000) asserted inquiry-based learning should never be considered the redeeming pedagogy for all of the learning problems experienced by students and educators. Employing inquiry-based learning pedagogy necessitated (a) adequate training for the educators; (b) administrator support; and (c) understanding inquiry-based learning required dynamic, lively participation by both the educator and the student (Friedman et al., 2010). Ensuring educators and students thoroughly understood how inquiry-based learning functioned in reforming science education prevented inquiry-based learning from being perceived as too challenging for students or deviating from required components (Friedman et al., 2010).

As noted previously, teachers are not inclined to change pedagogical practice without evidence of potential success. The contribution of the present study was to address the shortage of quantitative research studies specifically informing the effects of changes in pedagogical practices to include inquiry-based learning in a middle school classroom. The primary researcher believed a quantitative study provided the best opportunity to inform the research question, and add incremental empirical evidence to the body of knowledge.

Summary

Inquiry-based learning has created much interest among educators, but inquiry-based learning was not yet fully supported by strong empirical evidence. Nonetheless, inquiry-based learning appeared to be theoretically sound, rooted in venerable education theories (Bandura, 1971, 1977; Papert, 1993; Papert & Solomon, 1971; Piaget, 1926, 1954). Although teacher beliefs were a relevant issue, inquiry-based learning research needed to focus on student-centered measurable learning outcomes in order to establish credibility in practice. Toward that end, the present study endeavored to add incrementally to the quantitative findings informing inquiry-based learning as a potentially effective pedagogical approach (Bandura, 1971, 1977; Papert, 1993; Papert & Solomon, 1971; Piaget, 1926, 1954).

Research Questions and Hypotheses

The present research study focused on whether inquiry-based pedagogy actually brought about measurably improved learning outcomes. The focus of the present research methodology responded to the following research questions:

Research question and Hypothesis 1. Given a variable-controlled classroom environment, can inquiry-based learning be empirically demonstrated to produce learning outcomes different to a degree of measurable significance from a traditional didactic pedagogy (Research Question 1)? The primary researcher hypothesized in two variable-controlled classrooms differing only by pedagogical approach, students receiving inquiry-based learning would manifest statistically significantly higher posttest scores than students receiving traditional didactic pedagogy (Hypothesis 1). The primary researcher expected to confirm Hypothesis 1:

given two identically variable-controlled classrooms differing only by pedagogical approach, inquiry-based learning pedagogy would yield statistically significantly superior posttest results as compared to traditional didactic pedagogy.

Research question and Hypothesis 2. Given a variable-controlled classroom environment, can inquiry-based learning be empirically demonstrated to produce higher levels of engagement, increased satisfaction, and improved understanding of the lesson different to a degree of measurable significance from a traditional didactic pedagogy (Research Question 2)? The primary researcher hypothesized in two variable-controlled classrooms differing only by pedagogical approach, students receiving inquiry-based learning would manifest statistically significantly higher survey results than students receiving traditional didactic pedagogy (Hypothesis 2). The primary researcher expected to confirm Hypothesis 2: given two identically variable-controlled classrooms differing only by pedagogical approach, inquiry-based learning pedagogy would yield statistically significantly superior survey results as compared to traditional didactic pedagogy.

Research question and Hypothesis 3. Given a variable-controlled classroom environment, is there an empirically demonstrable correlation between student satisfaction and posttest scores (Research Question 3)? The primary researcher hypothesized in two variable-controlled classrooms differing only by pedagogical approach, there would be a measurable correlation between student satisfaction and posttest scores (Hypothesis 3). The primary researcher expected to confirm Hypothesis 3: given two identically variable-controlled classrooms differing only by pedagogical approach, students would manifest a direct, positive correlation between student satisfaction and learning outcomes.

Chapter 3: Methodology

Introduction

The present study employed the following methodology to investigate whether inquiry-based pedagogy actually brought about measurably improved learning outcomes, and empirically demonstrated the advancement of individual student achievement. The methodology sought to establish correlation; engaging a prediction design. By identifying variables and attending influences the primary researcher predicted an outcome through the articulation of hypothesis. Achieving the primary objectives of the present research design required two parallel procedures differing only by pedagogical approach.

The present study is best described as a quasi-experimental Nonequivalent Groups Design (NEGD) procedure that employed a pretest-training-posttest process in an effort to explicitly ascertain the inquiry-based learning pedagogy created the improvement in the student achievement on the posttest (Treiman, 2009; Trochim, 2006). The composition of specifically selected sixth-grade classes in a small private school clearly indicated both sample groups were small and non-random, which is the defining feature of quasi-experimental Nonequivalent Groups Design (Trochim, 2006). The present study was structured like a pretest-posttest randomized experiment, but because the two sixth-grade classes were specifically and analytically selected, there was an absence of random selection for the two groups in the study (Creswell, 2009; Trochim, 2006).

Nonequivalent Groups Design typically employs previously created groups analytically believed to be similar (Trochim, 2006). The present study contemplated a comparison of two classes generally similar in size and abilities, both of which were previously created to complete the students' academic schedule (Healey, 2009; Trochim, 2006). The comparison was therefore based on the analytical appearance of similarity between the two groups, as well as the suitability of the two groups for comparatively testing whether inquiry-based pedagogy actually brought about measurably improved learning outcomes for one group when compared to the second group. The intention of making such a comparison was to empirically demonstrate whether inquiry-based learning advanced individual student achievement, recognizing that any empirical findings would not be generalizable due the nature of the sample groups used in the comparison (Healey, 2009; Trochim, 2006).

Although the two study groups shared similar characteristics as a result of the processes through which they were created, there was neither assurance the two groups were precisely similar or indication the groups were significantly dissimilar. Moreover, the groups cannot attain complete statistical equivalency because the groups were not randomly generated and the number of students in the groups was small (Trochim, 2006). NEGD methodology ameliorates the characteristics of small sample comparisons, and was intended to enhance validity and reliability by applying appropriate statistical adjustment while clearly identifying any statistically significant findings as non-generalizable (Trochim, 2006). Basic Nonequivalent Groups Design is illustrated by Figure 2 below.

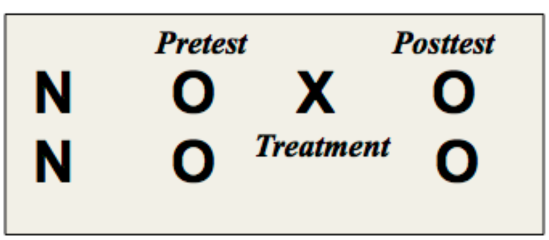

Figure 2. Basic non-equivalent groups design (NEGD). Adapted from "The non-equivalent groups design," by W. M. K. Trochim. 2006, *Web Center for Social Research Methods Knowledge Base*, para. 1. Reprinted with permission.

NEGD design statistically presented a particular mathematical challenge that had to be addressed in order to preserve the integrity, validity, and reliability of statistical analysis performed upon NEGD sample outcomes. Specifically, the reliability coefficient was appropriately adjusted to account for the small (i.e., $N<100$), non-random sample composition (Trochim, 2006). The sample size adjustment required a ‘reliability coefficient correction’ in order to ameliorate the effects of the small, non-random samples (Trochim, 2006). A key advantage of using Statistical Package for the Social Sciences Version 16.0 software (SPSS) for all statistical analysis in the present study was SPSS performed the adjustment of the reliability coefficient automatically, thus providing the primary researcher and end users of the study with confidence statistical procedures had been applied appropriately to the NEGD data in the present study (Trochim, 2006).

The first statistical procedure compared the pretest and posttest scores on a forty-question benchmark assessment created by the textbook publisher and provided as a resource tool for teachers of the sixth-grade science curriculum (McDougal & Littell, 2007). The comparison of the pretest and posttest scores within two grouped samples of sixth-grade students measured the effects of inquiry-based learning on students’ learning outcomes and also the effects of traditional didactic pedagogy on students’ learning outcomes (Research Question 1, Hypothesis 1) (Healey, 2009). The specific comparison was the effect of inquiry-based learning versus traditional didactic learning in relation to the students’ learning process as measured by pretest and posttest scores by means of independent samples *t* testing (Healey, 2009; Kirkpatrick & Feeney, 2009).

The second statistical procedure analyzed the responses to a survey where students rated personal engagement, satisfaction, and understanding of the unit of scientific study to measure the effect of inquiry-based learning versus traditional didactic learning on the students’ learning outcomes (Research Question 2, Hypothesis 2). The comparison of the survey scores between two grouped samples of sixth-grade students measured the satisfaction level attained during inquiry-based learning and also the satisfaction level attained during traditional didactic pedagogy. The specific comparison was the satisfaction level of inquiry-based learning versus traditional didactic learning as measured by numerical survey scores by means of dependent samples *t* testing (Kirkpatrick & Feeney, 2009).

The third statistical procedure employed correlation analysis to examine the relationship between the students' satisfaction and changes of posttest scores (Research Question 3, Hypothesis 3). The specific objective of the analysis was to determine if there was any statistically significant correlation within the samples between sample group learning outcomes as measured by posttest scores and satisfaction levels as measured by numerical survey scores (Healey, 2009; Kirkpatrick & Feeney, 2009).

The overall design schema was framed and driven by aforementioned research questions in keeping with MacCallum's (1998) assertion research procedures should reflect nature of the questions, and not the reverse. In general, the research questions and statistical procedures described above endeavored to illuminate changes in individual student achievement resulting from either inquiry-based or didactic learning processes, as well as student satisfaction and engagement with both pedagogies, thus enabling the researcher to ascertain detectable differences attributable to the use of inquiry-based learning.

The independent variable fundamental to the three proposed hypotheses was the engagement of research-based inquiry-based learning, the pedagogy either employed by the sixth-grade science teacher or not (Entin, 2002). The independent variable was limited to include only students enrolled within a sixth-grade science class at the proposed research site. The dependent variable for Hypothesis 1 was learner response to pedagogy as measured by a pretest and posttest forty-question benchmark assessment developed by the sixth-grade science textbook publisher (McDougal & Littell, 2007). The dependent variable for Hypothesis 2 was variances of learner responses to pedagogy as measured by the survey responses. The dependent variable for the Hypothesis 3 was correlation variances between changes in student satisfaction and changes of posttest scores (Entin, 2002).

The dependent variable for Hypothesis 1 was tested at the interval-ratio level of measurement by utilizing actual student test scores from the pretest and posttest (Entin, 2002; Healey, 2009; Kirkpatrick & Feeney, 2009). The dependent variable for Hypothesis 2 was also tested at the interval-ratio level of measurement utilizing student results from the survey (Entin, 2002; Healey, 2009; Kirkpatrick & Feeney, 2009). The dependent variable for Hypothesis 3 was tested at the interval-ratio level of measurement employing the learner response to pedagogy and the individual student responses to the satisfaction survey (Entin, 2002; Healey, 2009; Kirkpatrick & Feeney, 2009). By engaging three hypotheses, the primary researcher sought to discern (a) significant achievement gains, (b) corresponding learners' attitudes, and (c) whether there was a correlation between the achievement gains and the learners' attitudes as a result of the introduction of inquiry-based learning. The researcher further endeavored to establish inquiry-based learning not only increases student achievement, but also increases student satisfaction emanating from the learning process. Finally, the researcher sought to establish a measurable correlation between student satisfaction and increased student achievement.

Although numerical survey scores are technically ordinal in nature, by using a ten-point scale as a response mechanism on the survey, thus numericizing the results, the survey achieved quasi-interval ratio results testable within SPSS for the purpose of observing measurable trends in data (Thurstone, 1927, 1974). The present analysis falls within Thurstone's law of comparative judgment, upon which the behavioral science and education communities have long depended to reliably justify application of basic statistical analysis to survey results for the purpose of observing comparative trends between sample groups (Trochim, 2006).

The unit of analysis for the three present hypotheses will be the individual, specifically the individual student's response as defined by each student's pre- and posttest scores and post-procedure survey scores (Trochim, 2006). There was no risk of creating a hierarchy of units of analysis because there was no aggregation of individual test scores or survey responses, since the aggregate performance of the two sample groups was not being tested (Trochim, 2006). The statistical risk of a hierarchy of units of analysis occurs when a researcher attempts to apply random probability statistical analysis to non-random nonprobability samples (Healey, 2009; Trochim, 2006). In that situation, there is the potential for a progressive compounding of statistical errors, ultimately yielding invalid, unreliable outcomes (Healey, 2009; Trochim, 2006). Employment of the individual as the unit of analysis therefore preserved the integrity of statistical analysis for the non-random nonprobability samples deployed in the present study, as long as the reliability coefficient was adjusted appropriately for the sample size as discussed above (Healey, 2009; Trochim, 2006).

Sample Recruitment

The present study employed classic stratified random sampling (Creswell, 2009; Healey, 2009). A single-stage stratification sampling procedure was employed because the primary researcher had access and the ability to sample the students in the secondary school population of an established educational institution (Creswell, 2009). The study population were all secondary students at the research site, but the accessible sampling frame for purposes of the present study were all students in the sixth grade (Trochim, 2006). For purposes of the present quasi-experimental procedure, the primary researcher chose the grade level because of their age and adaptability as a feature of the population stratification (Creswell, 2009; Healey, 2009). Moreover, the intention of using single-stage stratification was to reduce selection bias in the non-random non-equivalent sample groups (Neuman, 2006). A single-stage stratification sampling procedure was distinctively different from a sample of convenience because the former is analytically derived based on specific environmental characteristics (Creswell, 2009).

The sixth grade was identified at the school chosen as the research site as the most effective stratum from within which to select test and control groups for two reasons. First, the sixth-grade teacher was highly experienced with both traditional didactic and inquiry-based learning pedagogical methodologies, as stated in the Introduction (above). Second, the sixth-grade students generally exhibit similar academic achievement levels. The two factors were significant in the stratification of the school population to determine the accessible sampling frame (Creswell, 2009; Trochim, 2006).

The accessible sample frame developed from the single-stage stratification sampling procedure included three sixth-grade classes, each comprised of approximately fifteen students. However, from within the accessible sampling frame, the primary researcher was able to stratify sixth-grade students into lists (Healey, 2009). Two of the sixth-grade science classes met on the same days of the week in the morning. By stratifying to include only the two classes meeting on the same day in the mornings, the primary researcher was better able to control environmental variables related to the flow of the school day for participating students as well as the participating faculty member.

Similarities of two of the class lists allowed the primary researcher to select two of the sixth-grade science classes to participate in the present study. The class list labeled Science 6-2 was the control sample group (Sample 1), and was composed of approximately fifteen 11-12 year old adolescents. Sample 1 experienced the teacher employing traditional, didactic pedagogy. The class list labeled Science 6-4 was the test sample group (Sample 2), and was composed of approximately fifteen 11-12 year old adolescents. Sample 2 was the inquiry-based learning test group and experienced inquiry-based learning methodology. The excluded third sixth-grade science class met after lunch on alternate weekdays from the two classes selected to participate in the study, and therefore manifested the possibility of learning experiences being affected by the weather, alternate day situations, and class at the end of the school day.

The primary researcher found limited research focused on the effects of inquiry-based learning on young students. Moreover, Friedman et al. (2010) stressed effective inquiry-based learning pedagogy necessitates adequate training for the educators, administrator support, and dynamic participation by both the educator and the student. The local sixth-grade teacher had diligently pursued inquiry-based learning by attending multiple professional development sessions focused on inquiry-based learning in the science classroom, thus demonstrating suitability for participation in the present study. Although the present study was relatively small in scope, the primary researcher desired to build on the opportunity created by the teacher's framework of inquiry-based learning pedagogy and render an initial, limited contribution to the body of research on the effectiveness of inquiry-based learning.

The findings of the present study are not generalizable because of the nature of NEGD samples, which are affected by the distinguishing traits of the individuals in the sampling frame as well as the sampling frame environment (Creswell, 2009; Trochim, 2006). Information obtained from the school's annual report (Private School Board, 2013) of the proposed research site indicated both lists of the sixth-grade classes (6-2 and 6-4) were approximately 50% male/50% female; 71% Caucasian/9% Black/7% Bi-Racial/6% Hispanic/7% Other; and predominantly upper middle class with one or both parents being college educated white-collar professionals. Any findings from the present study will therefore be pertinent only to ethnic or societal groups within the unique demographic and educational background groups at the research site (Creswell, 2009; Trochim, 2006).

Consent Procedures

Due to the nature of the present study and its employment of minor children as participants, the Nova Southeastern University Institutional Review Board (IRB, 2011) required the research proposal to be submitted for Expedited Review. In response to informed consent requirements stipulated by the IRB during the Expedited Review process, the primary researcher compiled an appropriate parent/guardian consent form as well as an age-appropriate child assent form. Upon receiving IRB approval to proceed with the present study, the primary researcher immediately began the process of contacting the parents and guardians of all minor participants, during which parents and guardians were fully informed as to the nature, purpose, and procedural approach of the study. As part of the conversation, the primary researcher explained child assent would be procured for all participants as part of an in-class whole group explanation of the study in which students were being solicited to participate.

Having received 100% parent/guardian informed consent and approval to proceed with child assent, the primary researcher met with each class of participants and fully explained the nature of the study and their parents and guardians had already agreed to their participation. During the meeting the primary researcher emphasized that participation was solely the personal choice of each student and each student should feel absolutely free to decline participation. At the conclusion of the child assent explanatory meeting, 100% of students in both classes signed the child assent form and agreed to participate in the study.

Instruments

The primary data collection instrument for Hypothesis 1 was an objective sixth-grade science test administered as both the pretest and posttest. As shown in Appendix G, the pretest and posttest were comprised of forty objective questions, each of which had four possible answers (a) through (d). The pretest and posttest employed in the present study were photocopied without alteration by the primary researcher from the official unit assessment supplementary booklet provided by the publisher of the sixth-grade science textbook (McDougal & Littell, 2007).

The validity of the test instrument was central to the credibility of the measures for the study (Lee, 1976; MacCallum, 1998). The supplementary booklet produced by the textbook publisher contained benchmark assessment instruments created by professional educators who are experts in the development of valid and reliable assessment tools (McDougal & Littell, 2007). Using the assessment instrument provided by the publisher ensured the integrity, validity, and consistency of the instrument when administered to both sample groups (Creswell, 2009; McDougal & Littell, 2007; Trochim, 2006). The teacher did not have access to the assessment instrument prior to administering the pretest and posttest, which further ensured the validity of the instrument. The test is digitally illustrated in Appendix G: Science Unit Objective Test for Pretest and Posttest, as well as physically photocopied and held in the primary researcher's custody until it was administered in order to ensure no portion of the objective test was manipulated in any way.

Prior to the designated time for administering the pretest, the primary researcher wrote the numbers 1 to 15 for Sample 1 and 16 through 20 for Sample 2 on individual slips of paper and placed them in a small box. Students in Science 6-2 (Sample 1) individually drew a number out of the box and wrote that number on the optical answer sheet (Scantron Corporation, 2007). The number could not be linked back to the student because it was randomly drawn out of a box. The primary researcher had no knowledge of the student's random number. Students placed only their answers and the randomly drawn number on the optical answer sheet for both the pretest and the posttest (Scantron Corporation, 2007). After studying the unit on volcanoes, the students placed their answers for the Posttest on a new optical answer sheet and again labeled the optical answer sheet with the number they drew prior to the Pretest (Scantron Corporation, 2007).

The primary researcher collected the optical answer sheets from the students immediately following their completion of the pretest and posttest (Scantron Corporation, 2007). The primary researcher processed the answer sheets through a machine capable of recognizing optical marks on the answer sheets (Scantron Corporation, 2007). The number identifier was the same number for each student on both the pretest and the posttest to ensure student pretest and posttest scores were accurately compared. All pretest, posttest, and survey scores were initially compiled in a Microsoft Excel spreadsheet for the preliminary analytical review of the means. The data was then entered into SPSS for inferential statistical analysis. In accordance with NEGD design, this process was precisely repeated to tabulate students' responses to the posttest.

Noting Golafshani's (2003) cautionary assertion the validity of quantitative research was contingent on the creation of the instrument, the primary data collection instrument for Hypothesis 2 was a non-psychometric online survey instrument developed by the primary researcher to compile testable data regarding student perceptions of the learning experience. Further acceding to Golafshani's directive instruments developed by quantitative researchers must be implemented in a consistent method following a prearranged process; the primary researcher developed an instrument to be administered to the sixth-grade science classes consistently using identical methods.

The survey was comprised of ten questions with a one to ten Likert scale response options. The questions asked the students to rate personal perception of engagement, understanding, and satisfaction during the unit of study. The survey was created employing the online survey tool SurveyMonkey (SurveyMonkey, Inc., 2013). The survey was administered via an online provider by the primary researcher during the class period on the next class day following the administration of the posttest. The sixth-grade science teacher was not present during the administration of the survey and students were informed personal responses would not be shared with the teacher.

Numericizing a survey response scale presented the validity and reliability problem of assigning an appropriate scale to human attitudes or tendencies. However, Black (1999) addressed the validity and reliability problem, pointing out an analysis of the dimension of an individual trait is merely a method to attach a sign of comparative value to a specific attribute. In other words, Black argued if the survey is appropriately designed for the particular respondents for which the survey is intended, the scale need not precisely represent human behavior. Rather, it is necessary for a consistent scale to be used which can be effectively compared and tested using statistical means, such as SPSS. Black asserted if the survey scale is designed in a consistent manner and is tested appropriately, the primary researcher should be successful in protecting the construct design validity and reliability. Based on Black’s discussion in conjunction with Thurstone’s (1927) law of comparative judgment, the primary researcher therefore believes the integrity of the post-procedure survey design was sufficient to establish valid and reliable comparative statistical results when tested using SPSS, a venerable software application.

There was no collection of information to be analyzed following the conclusion of the proposed research study (e.g. age, gender, and ethnicity). A total of 28 individual student subjects completed the following process:

Step 1. All sixth-grade students in Science 6-2 and Science 6-4 classes, with the exception of one student in each class who was excused because of illness, completed the Pretest individually by placing answers on an optical answer sheet (Scantron Corporation, 2007).

Step 2. All sixth-grade students in Science 6-2 and Science 6-4 classes, with the exception of one student in each class who was excused because of illness, completed the unit of study in either an inquiry-based learning environment or a traditional didactic classroom.

Step 3. All sixth-grade students in Science 6-2 and Science 6-4 classes, with the exception of one student in each class who was excused because of illness, completed the Posttest individually (exact same test as Pretest) a second time by placing answers on an optical answer sheet (Scantron Corporation, 2007).

Step 4. All sixth-grade students in Science 6-2 and Science 6-4 classes, with the exception of one student in each class who was excused because of illness, individually completed the online Post Lesson Student Survey.

Research Design

Detailed explanations of procedural Steps 1-4 (above) are described below:

Step 1. As stated previously, the present study employed classic stratified random sampling (Healey, 2009). The most significant component of the analysis was to ensure students in Sample 1 experienced traditional, didactic teaching pedagogy and students in Sample 2 experienced inquiry-based learning pedagogy. The analysis was achieved by working with the administration and faculty of the research site in Houston, Texas, where the primary researcher served as a member of the faculty and administrative staff. The present study was submitted to and approved by the school principal prior to commencement of Step 1.

The teacher participated in the research project and worked with the primary researcher to develop the traditional, didactic unit of study and the inquiry-based learning unit of study. The teacher and the primary researcher concurred the curriculum unit of study on volcanoes should be the unit employed in the research (S. Majors, personal communication, April 12, 2013). The primary researcher met with all of the sixth-grade students enrolled in Science 6-2 and in Science 6-4 during a class period and gave them 30 minutes to complete the 40 multiple choice questions on the pretest. Upon completion of the pretest, the optical answer sheets were immediately collected by the primary researcher (Scantron Corporation, 2007). The primary researcher then processed the answer sheets through a machine capable of recognizing optical marks on the optical answer sheets (Scantron Corporation, 2007). Finally, the primary researcher tabulated the data obtained from pretest scores into Microsoft Excel 2010 and SPSS.

Step 2. Following the administration by the primary researcher of the pretest over the material contained in the science unit, the teacher employed (a) traditional didactic pedagogy with Sample 1 (Science 6-2) and (b) inquiry-based learning pedagogy with Sample 2 (Science 6-4) (S. Majors, personal communication, April 12, 2013).

Step 3. Immediately following the completion of the unit of study on volcanoes, the primary researcher administered the posttest using precisely the same methodology as employed for the pretest (Scantron Corporation, 2007; S. Majors, personal communication, April 12, 2013).

The primary researcher then tabulated the data obtained from posttest scores into Microsoft Excel 2010 and SPSS.

Step 4. During the class period on the school day following the administration of the posttest, the primary researcher met with the Sample 1 and Sample 2 classes to explain how they would access the online survey and enter their responses. The primary researcher immediately emailed the link for the survey to the participants (i.e., during class), and instructed them to answer the survey questions based on personal perceptions about the individual learning process during the science unit focused on volcanoes. Each student employed the same identifying number in SurveyMonkey (2013) originally written on their pretest and posttest response sheets. Once all participants in both sample groups had submitted responses to the online survey during class, the primary researcher tabulated the data obtained from survey responses into Microsoft Excel 2010 and SPSS. Submission of the online survey concluded all subjects' participation in the research project.

Data Analysis

A key objective of the present study was to contribute to empirically tested quantitative findings in the body of knowledge. The fundamental design characteristic of the present study involved testing two sample groups for variance across a specific dependent variable, while leaving the independent variable unaffected, which is the essential design feature of experimental research (Ellis & Levy, 2009, Healey, 2009). Inferential statistical testing of Research Question 1, Hypothesis 1 employed independent samples *t* testing within samples performed by SPSS (Healey, 2009; Kirkpatrick & Feeney, 2009). Inferential statistical testing of Research Question 2, Hypothesis 2 employed dependent samples (i.e., matched pairs) *t* testing between samples performed by SPSS (Healey, 2009; Kirkpatrick & Feeney, 2009). Inferential statistical testing of

Research Question 3, Hypothesis 3 employed correlation analysis within the samples performed by SPSS (Healey, 2009; Kirkpatrick & Feeney, 2009).

Limitations

Four characteristics of the sample groups and the research site of the present study preclude the study from being characterized as generalizable experimental research:

1. By specifically stratifying grade levels and selecting sixth-grade science classes for comparison, the primary researcher was inherently not employing groupings for the independent variable grounded in a normally occurring characteristic, inasmuch as the sample group participants were not naturally grouped, but rather grouped by operation of the school's institutional process (Ellis & Levy, 2009).

2. The intrinsic composition of specifically selected sixth-grade classes in a small private school with limited demographic diversity clearly indicated both sample groups would be small and non-random and did not ensure a theoretical sample upon which generalizations can be implied upon greater populations without further study (Trochim, 2006). The described composition is the defining feature of quasi-experimental Non-equivalent Groups Design (NEGD) research, which implies replication would be necessary in order to accumulate sufficient data to observe more broadly applicable meta-analytical findings (Healey, 2009; Trochim, 2006).

3. The primary researcher was a significant professional operative within the environment of the small private school described above. However, the primary researcher was also a seasoned CITI-licensed quantitative researcher with substantial prior experience serving as research assistant for a quantitative social sciences study conducted at NSU. The primary

researcher's prior research experience afforded the researcher sufficient insight to limit bias and influence on the present study to the fullest extent possible.

4. The teacher who imposed the inquiry-based learning process upon Sample 2 was also the teacher withholding the inquiry-based learning process from Sample 1 by imposing the traditional didactic learning process upon Sample 1. Although the practitioner was highly trained and experienced, there was potential for the practitioner to manifest a tendency to express the need to nurture students who were struggling with a particular pedagogical approach. Significantly, for purposes of the present study it was not assumed either inquiry-based learning or traditional didactic pedagogy would be positively or negatively received by students. However, it was possible the practitioner's nurturing tendency or personal pedagogical bias could affect student performance. As will be discussed in Chapter 5, neither manifestation of a nurturing tendency nor pedagogical bias was observed by the primary researcher.

Chapter 4: Results

Introduction

The essential purpose of this study was to empirically compare the effectiveness of two forms of pedagogy: traditional didactic presentation versus inquiry-based learning. This purpose was fundamentally accomplished by comparing and contrasting two closely matched sixth-grade science classes. The research design sought first to make evident a variance of significance between two groups of sixth-grade students enrolled in a private school pertaining to pretest and posttest scores, and second to examine variances in their satisfaction survey scores. The objective of the analysis was to determine whether any divergence between samples was a result of differing pedagogies, differing satisfaction levels, or both factors. The following discussion will endeavor to illuminate the statistical path toward those determinations and also present the detailed statistical findings leading to a conclusive perspective on the three research questions.

Analytical Approach and Composition of Data

The research design of the study focused on a standard two-sample case in which the sample effect is the divergence between the sample statistics (Healy, 2009). Since small samples were employed in the study, less than one hundred members, the methodology deemed appropriate was a *t* test data analysis strategy to compare sample means, thereby determining the significant region under the normal curve and establishing improbable sample results (Healy, 2009). In the applied research study, analysis specifically focused on characterizing the composition of the two samples was not necessary in order to accept or reject the stated hypotheses, thus eliminating the need for linear regression (Treiman, 2009). However, correlation analysis was applied to explore the relationship between variables (Healy, 2009; Treiman, 2009).

When examining the variance in means between small samples, the researcher presumed the variances of the samples of the study equivalent to successfully validate the supposition of a normal sampling distribution and to create a collective assessment of the standard deviation of sample dissemination (Healey, 2009). The operational presumption would be problematical within non-equivalent groups designs (NEGD) in which samples are normally small and non-random, because large sample size and randomness are significant aspects of tests based on the normal sampling distribution (Trochim, 2006). The *t* distribution adjusts for small sample sizes by including a calculation for degrees of freedom, which modifies the critical region under the normal curve to adapt for the mathematical effects of the smaller sample (Healey, 2009). Non-random samples also present a challenge concerning the assumption of known population means and variances, because in a non-random sample the sample population may not be typical of the broader population (Healey, 2009). The researcher employed NEGD *t* testing assumptions using small non-random samples which, while appropriately adjusted as described above, cannot be generalized to larger samples or the broader population (Healey, 2009).

The descriptive analysis of data was completed by the researcher employing Microsoft Excel 2010. Spreadsheets were created for the following categories: (a) pretest scores, (b) posttest scores, and (c) post lesson survey responses. Pretest and posttest scores by sample groups are shown in Appendix B and Appendix C shows survey responses by sample groups. Scores for the pretest, posttest, and survey responses were entered into a spreadsheet for each participant in Sample 1 and Sample 2. After the data was entered into the spreadsheets, researcher employed Microsoft Excel 2010 to calculate the percentage improvement of the mean scores on the pretest and posttest for the two sample groups, both individually and in the aggregate. Further, the mean ranking for survey responses for the two sample groups was calculated in Microsoft Excel 2010. Analysis established the descriptive statistical baseline by which researcher was able to judge the appropriate use of either one-tailed or two-tailed *t* testing, by which one-tailed *t* testing was deemed applicable (Healey, 2009).

The most effective method of inferential statistical analysis upon the data was to load the pretest and posttest score data and the survey score data into a statistical software package such as SPSS and engage the software to complete the mathematical and statistical mechanics of *t* testing (Healey, 2009; Trochim, 2006). Appendix D displays the SPSS Version 16.0 compilation of the science unit pretest and posttest score data by group. Appendix E contains the SPSS Version 16.0 compilation of the survey score data by sample group. Appendix F presents the SPSS Version 16.0 compilation of the survey correlation analysis. Employing SPSS afforded the advantage of accuracy, which also augmented the overall validity and reliability of the study. As a result of the accuracy and venerable research history of SPSS, it was realistic to expect SPSS *t* test results would provide sufficient analytical insight to either confirm or disconfirm the three research questions and related hypotheses postulated by the present study (Healey, 2009; Kirkpatrick & Feeney, 2009).

Analysis of Research Question and Hypothesis 1

The objective of data reduction and analysis for Research Question 1, Hypothesis 1 was to determine if the classroom environment inquiry-based learning (IBL) would produce learning outcomes different to a degree of measurable significance from a traditional didactic pedagogy. Researcher anticipated finding in two variable-controlled classrooms differing only by pedagogical approach, students receiving inquiry-based learning would manifest statistically significantly superior posttest scores than students receiving traditional didactic pedagogy.

The analytical review of the descriptive statistics, sample means for the posttest scores, indicated a conspicuous difference between the improvement of the mean scores from the pretest to the posttest for the two sample groups of sixth-grade students. As shown in Table 1, the mean score increase from the pretest to the posttest of the participants in Sample 1 (didactic) was a significantly lower percentage increase than the Sample 2 (IBL) percentage increase.

Table 1

Pretest and Posttest Mean By Sample Group

	Sample 1			Sample 2	
	Pretest	Posttest		Pretest	Posttest
M	46.43	51.88	*M*	44.46	60.83
	11.73% Increase			36.81% Increase	

Note: *M* = Mean.

The fundamental value of performing the initial descriptive statistical analysis of mean differences between the samples is to afford the researcher a reasonable basis for predicting the directional change in the mean scores. Information is crucial for *t* testing of Research Question 1, Hypothesis 1 because if the researcher can estimate the projected directionality of the mean differences between the sample groups, then the researcher can defend using a one-tailed *t* test (Healey, 2009). Descriptive statistical analyses of detailed scores for the pretest and posttest therefore validated use of one tailed *t* testing, given the clear positive direction of the change in mean scores (Appendix B; Healey, 2009).

Based upon the implications of the increase in the mean scores on the posttest of the two sample groups means presented in Table 1, researcher directly tested Research Question 1, Hypothesis 1 by inferentially statistically comparing changes in pretest and posttest mean scores as presented in Table 2. Sample 1 (didactic) and Sample 2 (IBL) were compared using one-tailed one-sample *t* testing to test the significance of mean score directional tendencies (Healey, 2009; Kirkpatrick & Feeney, 2009).

Table 2

Independent Samples t Test Results for Sample 1 and 2 Pretest and Posttest Scores†

Samples 1 & 2	*N*	*M*	Mean Difference	*SD*	*df*	$t_{(critical)}$	$t_{(obtained)}$
Pretest: 1	14	46.43	1.96	9.94	26	1.706	.421
Pretest: 2	14	44.46		14.35			
Posttest: 1	14	52.50	1.60	11.85	26	1.706	-1.347
Posttest: 2	14	50.89		12.62			

Note. N = Number of participants. *M* = Mean. *SD* = Standard deviation. *df* = Degrees of freedom.
†1-tailed, $p < .05$, $\alpha = .05$.

Independent-samples *t* testing revealed no statistically reliable difference between the means of pretest scores generated by Sample 1 (didactic) and Sample 2 (IBL) (Sample 1: *M* = 46.43, *SD* = 9.94; Sample 2: *M* = 44.46, *SD* = 14.35; $t(26) = 1.706$, $p < .05$, $\alpha = .05$). Independent-samples *t* testing also revealed no statistically reliable difference between the means of posttest scores generated by Sample 1 (didactic) and Sample 2 (IBL) (Sample 1: *M* = 52.50, *SD* = 11.85; Sample 2: *M* = 50.89, *SD* = 12.62; $t(26) = 1.706$, $p < .05$, $\alpha = .05$) (Elvers, 2011; see Appendix D: SPSS Output for Testing of Hypothesis 1). The analytical review of the mean percentage increase from the pretest scores to the posttest scores for Sample 1 (didactic) and Sample 2 (IBL) employing a one-sample *t* test therefore revealed there was no statistically significant difference between the pretest or posttest scores of the two sample groups, despite the notable direction of change observed during the preliminary review of the descriptive statistics.

Upon comparing pretest and posttest scores via inferential statistics within the sample groups, a statistically significant score increase was measured within both samples as shown in Table 3. Finding was not pertinent for purposes of informing Research Question 1, Hypothesis 1 since merely implies students in both samples increased personal learning to some extent. However, as shown in Table 3, a finding worthy of note from analysis was the variance in the Sample 1 scores increased from the pretest to the posttest, but the Sample 2 score variance decreased from the pretest to the posttest, indicating less variance in the inquiry-based learning group than in the didactic group. The important implications of the differing directions of variance between the two samples will be discussed in Chapter 5.

Table 3

One Sample t Test Results Within Sample 1 and 2 Pretest and Posttest Scores[†]

Samples 1 & 2	*N*	*M*	Mean Difference	*SD*	*df*	$t_{(critical)}$	$t_{(obtained)}$
Pretest: 1	14	46.43	-53.57	9.94	13	1.771	-20.17
Posttest: 1	14	52.50	-47.50	11.85			-15.00
Pretest: 2	14	44.46	-55.54	14.35	13	1.771	-14.48
Posttest: 2	14	50.89	-49.11	12.62			-14.56

Note. *N* = Number of participants. *M* = Mean. *SD* = Standard deviation. *df* = Degrees of freedom. [*]1-tailed, $p < .05$, $\alpha = .05$, test value = 100.

One-sample *t* testing thus revealed a statistically reliable difference between the means of pretest and posttest scores generated by Sample 1 (didactic) (Sample 1 Pretest: $M = 46.43$, $SD = 9.94$; Sample 1 Posttest: $M = 52.50$, $SD = 11.85$; $t(13) = 1.771$, $p < .05$, $\alpha = .05$, test value = 100). One-sample *t* testing also revealed a statistically reliable difference between the means of pretest and posttest scores generated by Sample 2 (IBL) (Sample 2 Pretest: $M = 44.46$, $SD = 14.35$; Sample 2 Posttest: $M = 50.89$, $SD = 12.62$; $t(13) = 1.771$, $p < .05$, $\alpha = .05$, test value = 100) (Elvers, 2011; see Appendix D: SPSS Output for Testing of Hypothesis 1). As noted, finding was not pertinent for purposes of informing Research Question 1, Hypothesis 1, except to the extent of observing differences in sample variance.

The objective of data reduction and analysis for Research Question 1, Hypothesis 1 was to determine if in the classroom environment inquiry-based learning would produce learning outcomes different to a degree of measurable significance from a traditional didactic pedagogy. Inferential *t* testing of the increase in the mean scores on the posttest from the two sample groups therefore disconfirmed Hypothesis 1 which postulated in two variable-controlled classrooms differing only by pedagogical approach, students receiving inquiry-based learning would manifest statistically significantly superior posttest scores than students receiving traditional didactic pedagogy.

Analysis of Research Question and Hypothesis 2

Data reduction and analysis for Research Question 2, Hypothesis 2 was to determine if in the classroom environment inquiry-based learning would produce higher levels of student engagement, increased satisfaction, and improved understanding of the lesson different to a degree of measurable significance from a traditional didactic pedagogy. Preliminary analytical review of the descriptive statistics indicated no significant difference between the levels of student engagement, satisfaction, and understanding of the lesson when comparing the inquiry-based learning environment to the traditional didactic pedagogy. Based on the preliminary descriptive statistical analysis, Table 4 indicates little observable difference between the responses on the post lesson student survey for Sample 1 (didactic) compared to the means of the responses of the post lesson student survey for Sample 2 (IBL).

Table 4
Post Lesson Student Survey Mean By Sample Group

Survey Questions	*M* Sample 1	*M* Sample 2
1 FG?	5.29	5.00
2 CU?	4.64	4.50
3 BW?	5.00	4.50
4 KM?	6.29	4.79
5 TO?	5.14	5.71
6 WR?	5.36	4.86
7 SI?	5.29	5.36
8 WN?	5.79	4.93
9 WL?	5.93	5.29
10 FH?	6.36	5.50

*Note***.** *M* = Mean. FG? = Feel Good?; CU? = Can use?;
BW? = Best way?; KM? = Know more?; TO? = Tell others?;
WR? = Will remember?; SI? = Stay interested?;
WN? = Wanted next?; WL? = Worth learning?;
FH? = Felt happy?
Taken from Appendix A: Student survey, C. G. Ziemer, 2013.

Table 5 displays the results of inferential statistical *t* testing of responses on the student survey. Those findings indicated there was no statistically measurable difference in the responses of Sample 1 and Sample 2 for any of the ten survey questions.

Table 5

Matched Pairs t Test Results for Student Survey Scores[*]

Samples 1 & 2		*N*	*M*	Mean Difference	*SD*	$t_{(obtained)}$	*df*	*Sig.*(2-tailed)*
Question 1	1: Didactic	14	5.29	.286	2.199	.308	26	.761
	2: IBL	14	5.00		2.689			
Question	1: Didactic	14	4.64	.143	2.763	.147	26	.885

2	2: IBL	14	4.50		2.378			
Question 3	1: Didactic	14	5.00	.500	3.038	.422	26	.676
	2: IBL	14	4.50		3.228			
Question 4	1: Didactic	14	6.29	1.500	2.946	1.448	26	.159
	2: IBL	14	4.79		2.517			
Question 5	1: Didactic	14	5.14	-.571	2.627	-.491	26	.628
	2: IBL	14	5.71		3.474			
Question 6	1: Didactic	14	5.36	.500	2.818	.476	26	.638
	2: IBL	14	4.86		2.742			
Question 7	1: Didactic	14	5.29	-.071	3.583	-.058	26	.954
	2: IBL	14	5.36		2.925			
Question 8	1: Didactic	14	5.79	.857	2.992	.799	26	.431
	2: IBL	14	4.93		2.674			
Question 9	1: Didactic	14	5.93	.643	3.222	.504	26	.618
	2: IBL	14	5.29		3.518			
Question 10	1: Didactic	14	6.36	.857	2.341	.896	26	.379
	2: IBL	14	5.50		2.710			

Note. N = Number of participants. *M* = mean. *SD* = Standard deviation. *df* = Degrees of freedom.
*2-tailed, $p < .05$, $\alpha = .05$.

The objective of data reduction and analysis for Research Question 2, Hypothesis 2 was to determine if in the classroom environment inquiry-based learning would produce higher levels of student engagement, increased satisfaction, and improved understanding of the lesson different to a degree of measurable significance from a traditional didactic pedagogy. The researcher thus anticipated observing measurable differences in student engagement, satisfaction, and understanding outcomes between Sample 1 (didactic) and Sample 2 (IBL).

The findings indicated there was no statistically measurable difference in the responses of Sample 1 and Sample 2 for any of the ten survey questions. A paired samples *t* test revealed no statistically reliable differences between the responses on the Post Lesson Student Survey for Sample 1 (didactic) and Sample 2 (IBL) for any of the following survey questions: Question 1 (FG) Sample 1 ($M = 5.29$, $SD = 2.199$), Sample 2 ($M = 5.00$, $SD = 2.689$), $t(26) = 1.706$, $p = .05$, α = .05; Question 2 (CU) Sample 1 (*M* = 4.64, *SD* = 2.763), Sample 2 (*M* = 4.50, *SD* = 2.378), *t*(26) = 1.706, *p* = .05, α = .05; Question 3 (BW) Sample 1 (*M* = 5.00, *SD* = 3.038), Sample 2 (*M* = 4.50, *SD* = 3.228), *t*(26) = 1.706, *p* = .05, α = .05; Question 4 (KM) Sample 1 (*M* = 6.29, *SD* = 2.946), Sample 2 (*M* = 4.79, *SD* = 2.517), *t*(26) = 1.706, *p* = .05, α = .05; Question 5 (TO) Sample 1 (*M* = 5.14, *SD* = 2.627), Sample 2 (*M* = 5.71, *SD* = 3.474), *t*(26) = 1.706, *p* = .05, α = .05; Question 6 (WR) Sample 1 (*M* = 5.36, *SD* = 2.818), Sample 2 (*M* = 4.86, *SD* = 2.742), *t*(26) = 1.706, *p* = .05, α = .05; Question 7 (SI) Sample 1 (*M* = 5.29, *SD* = 3.583), Sample 2 (*M* = 5.36, *SD* = 2.925), *t*(26) = 1.706, *p* = .05, α = .05; Question 8 (WN) Sample 1 (*M* = 5.79, *SD* = 2.992), Sample 2 (*M* = 4.93, *SD* = 2.674), *t*(26) = 1.706, *p* = .05, α = .05; Question 9 (WL) Sample 1 (*M* = 5.93, *SD* = 3.222), Sample 2 (*M* = 5.29, *SD* = 3.518), *t*(26) = 1.706, *p* = .05, α = .05; Question 10 (FH) Sample 1 (*M* = 6.36, *SD* = 2.341), Sample 2 (*M* = 5.50, *SD* = 2.710), *t*(26) = 1.706, *p* = .05, α = .05 (Elvers, 2011; see Appendix E: SPSS Output for Testing of Hypothesis 2).

Inferential statistical *t* testing of responses to the post lesson student survey from Sample 1 and Sample 2 therefore disconfirmed Hypothesis 2 which postulated in two variable-controlled classrooms differing only by pedagogical approach, students receiving inquiry-based learning would manifest statistically significantly higher survey results than students receiving traditional didactic pedagogy.

Analysis of Research Question and Hypothesis 3

The objective of data reduction and analysis for Research Question 3, Hypothesis 3 was to determine if in the classroom environment inquiry-based learning would produce a measurable correlation between student satisfaction and any change in the student posttest scores. The survey achieved quasi-interval ratio results testable within SPSS Version 16.0 for the purpose of observing measurable trends in the data (Thurstone, 1927, 1974). The analysis fell within Thurstone's (1927) Law of Comparative Judgment, which asserted the analytical validity of numericizing survey results using a consistent, measurable scale for the purpose of observing comparative trends between sample groups (Trochim, 2006).

Table 6 indicates Pearson's Correlation (*r*) analysis revealed no measurable correlation between increases in test scores and post lesson student survey results for Sample 1 (didactic). However, Table 6 also indicates there was a strong correlation between positive changes in test scores and post lesson student survey results in Sample 2 (IBL) for questions 2, 8, and 9.

Table 6

Pearson Correlation Comparing Posttest Scores to Post Lesson Student Survey Responses

Samples 1 & 2		*N*	*r*	*Sig.*(1-tailed)†
Question 1	1: Didactic	14	.003	.496
	2: IBL	14	-.443	.056
Question 2	1: Didactic	14	-.188	.260
	2: IBL	14	-.789*	.000 *
Question 3	1: Didactic	14	.209	.237
	2: IBL	14	-.315	.137
Question 4	1: Didactic	14	-.183	.266
	2: IBL	14	.270	.176
Question 5	1: Didactic	14	.044	.440
	2: IBL	14	-.398	.079
Question 6	1: Didactic	14	-.211	.235
	2: IBL	14	-.355	.106

Question 7	1: Didactic	14	-.087	.384
	2: IBL	14	-.126	.334
Question 8	1: Didactic	14	.040	.446
	2: IBL	14	-.529*	.026*
Question 9	1: Didactic	14	-.173	.277
	2: IBL	14	-.490*	.037*
Question 10	1: Didactic	14	.066	.411
	2: IBL	14	-.389	.084

Note. N = Number of participants. r = Pearson Correlation. †$p < .05$, α = .05. *Significant at 0.05.

Pearson Correlation (r) testing thus revealed no statistically significant correlation between posttest scores and post lesson student survey responses for Sample 1 (didactic) ($p < .05$, α = .05). However, Pearson Correlation (r) testing revealed statistically significant correlation between posttest scores and post lesson student survey responses for Sample 2 (IBL) in regard to three survey questions: Question 2 (CU) (N = 14, r = -.789, p = .000, α = .05; Question 8 (WN) (N = 14, r = -.529, p = .026, α = .05; and Question 9 (WL) (N = 14, r = -.490, p = .037, α = .05 (Elvers, 2011; see Appendix D: SPSS Output for Testing of Hypothesis 1).

Based on findings, there appears to be a positive correlation between student satisfaction and positive changes in posttest scores for the inquiry-based learning sample not appearing to exist for the didactic sample. Correlational analysis of the responses to the post lesson student survey and the increase in the student posttest scores therefore confirmed Hypothesis 3: given two identically variable-controlled classrooms differing only by pedagogical approach, students manifested a direct, positive correlation between student satisfaction and learning outcomes.

Chapter 5: Discussion

The purpose of the applied research study was to evaluate whether inquiry-based pedagogy would actually bring about measurably improved learning outcomes, and be empirically demonstrated to advance individual student achievement. During the past twenty years inquiry-based learning has emerged from seminal education theories, despite the absence of strong empirical evidence (Bandura, 1971, 1977; Papert, 1993; Papert & Solomon, 1971; Piaget, 1926, 1954). As stated previously, the National Research Council Committee on a Conceptual Framework for New K-12 Science Education Standards, Board on Science Education, Division of Behavioral and Social Sciences and Education (2012) clarified the definition of inquiry-based learning by emphasizing the process must connect or involve students in a scientifically oriented question. Further, the theoretical framework emphasized inquiry-based learning should include a variety of mental, social, and physical applications (National Research Council Committee on a Conceptual Framework for New K-12 Science Education Standards, Board on Science Education, Division of Behavioral and Social Sciences and Education, 2012). Accordingly, the National Research Council emphasized the importance of students becoming personally involved in the learning process instead of merely observing or listening to a teacher (National Research Council Committee on a Conceptual Framework for New K-12 Science Education Standards, Board on Science Education, Division of Behavioral and Social Sciences and Education, 2012).

In that light, the applied research study was composed of two sections of sixth-grade science classes at the secondary campus of a small private school in Houston, Texas. A total of 28 sixth-grade student participants completed the pretest, posttest, and post lesson student survey during the final term of the 2012-2013 school year. The data from the 28 student scores and responses was analytically reviewed. Chapter 5 presents an analysis of data presented in Chapter 4, an overview of the conclusions, examines limitations, and offers recommendations for future research.

The focus of Research Question 1 and the driving motivation for the present study was whether inquiry-based pedagogy would actually bring about measurably improved learning outcomes, which was disconfirmed although a significant variance issue was revealed and will be discussed below. The objective for Research Question 2 was to determine if inquiry-based learning would produce higher levels of student engagement, increased satisfaction, and improved understanding of the lesson different to a degree of measurable significance from traditional didactic pedagogy. Research Question 2, Hypothesis 2 was disconfirmed. Finally, the objective of Research Question 3 was to determine if inquiry-based learning would produce a measurable correlation between student satisfaction and any measurable change in student posttest scores. Significantly, this correlation was confirmed, as will be discussed below.

Statistical analysis of Research Question 1 underscored a key reason for educators to avoid drawing broad conclusions and rendering high-certainty pedagogical assertions based solely on basic descriptive statistics such as changes in test score averages. When the primary researcher performed preliminary analytic review of the descriptive data for Research Question 1 changes in average test score were observed to indicate a substantial difference in the increase of the posttest scores between the two sample groups. Sample 2 (IBL) experienced a 36.81% increase compared to the 11.73% increase experienced by Sample 1 (didactic). However, inferential statistical testing of Research Question 1disconfirmed Hypothesis 1 in the present study because the method revealed there was in fact no inferentially statistically significant difference in the increase of pretest-posttest scores between Sample 1 and Sample 2.

A statistically significant difference was observed between pretest and posttest scores within both groups of student participants, which was expected inasmuch as by design, all students received training in the science unit. However, in a striking and unexpected finding, the variance in the scores for Sample 1 (didactic) increased from the pretest to the posttest whereas the variance in the scores for Sample 2 (IBL) decreased from the pretest to the posttest. The implication is both groups learned, but inquiry-based learning may have brought about increased social cohesion during the learning process, thus validating Bandura's (1971, 1977) Social Learning Theory.

Inferential *t* testing of the responses on the post lesson student survey from the two sample groups disconfirmed Hypothesis 2 which asserted in two variable-controlled classrooms differing only by pedagogical approach, students receiving inquiry-based learning would manifest statistically significantly higher survey results than students receiving traditional didactic pedagogy). Although the data indicated moderate variance in various student responses, students in Sample 2 (IBL) did not indicate a statistically significantly higher satisfaction and engagement rating when compared to the students in Sample 1 (didactic). In general, both sample groups manifested moderate satisfaction and engagement levels regardless of pedagogical approach.

Hypothesis 1 and Hypothesis 2 were therefore disconfirmed. However, the primary researcher confirmed Hypothesis 3, a significant correlation between the inquiry-based learning environment, student satisfaction, and the increase in student posttest scores. The researcher noted inquiry-based learning students manifested this correlation in regard to three topics: (a) whether students thought the information would be used later in life, (b) whether students desired to learn the next piece of information, and (c) whether students felt the topic was worth learning.

While observing the learning process of the two sample student groups, the primary researcher observed within the didactic learning environment the focus and engagement of the students appeared inconsistent. By comparison, students in the inquiry-based learning environment appeared enthusiastic and evidently engaged throughout the learning process as each team focused on understanding the dynamics of a volcano, developed inquiries, and created individual and collective responses. In debriefing with the teacher following the post lesson survey, the teacher commented about the consistent, enthusiastic engagement of the teams in the inquiry-based learning process. One significant teacher observation was in the teacher's experience, students who had routinely had difficulty succeeding in the didactic science classroom appeared to flourish in the inquiry-based learning classroom, often becoming leaders among peers as a result of new found enthusiasm for the learning process.

Implications

Based on findings of the present research study, the two teaching pedagogies appeared equally effective. Moreover, the increase in the posttest scores of all of the students indicated the learning process in both the inquiry-based learning and didactic environment manifested mutually positive learning outcomes. However, students in Sample 2, (IBL) appeared to manifest a more cohesive collective learning outcome (i.e., less variance was measured within the group). Observed cohesion is consistent with Bandura's (1971, 1977) Social Learning Theory, which asserted cohesion in a group supports the success of the learning process. Moreover, the observed collective learning outcome suggests social cohesion also drives the strong correlation between student satisfaction and posttest scores observed in Sample 2 (IBL). Nonetheless, the disconfirmation of Hypothesis 1 and Hypothesis 2 should resonate as a cautionary note suggesting educators should not be quick to assume either traditional didactic pedagogy is technically ineffective or inquiry-based learning pedagogy is technically superior. Clearly the findings of the present study do not support such a stark contrast in those two venerable pedagogical approaches.

Limitations

As anticipated in Chapter 3, four characteristics of the sample groups and the research site were expected to preclude the present study from being characterized as generalizable experimental research.

1. The sample stratification schema employed by the primary researcher resulted in samples largely homogenous demographically and socioeconomically. Moreover, the sample groups were created by an institutional process (i.e., class registration) rather than selection from the broader population (Ellis & Levy, 2009).

2. The small and non-random sample composition necessitated the use of Non-equivalent Groups Design (NEGD), which by its statistical nature cannot be generalized to the general population despite statistical adjustments intended to ensure the validity and reliability of the findings as compiled in SPSS (Healey, 2009; Trochim, 2006).

3. A third characteristic noted in Chapter 3 the primary researcher was a significant professional operative within the environment of the research site. The researcher's role as employee could have posed problems of researcher bias or coercion in conjunction with the fourth limitation.

4. Specifically, the teacher imposing the inquiry-based learning process upon Sample 2 (IBL) was also the teacher withholding the inquiry-based learning process from Sample 1 by imposing the traditional didactic learning process upon Sample 1.

Both the third and fourth limitations were addressed by a careful ongoing process of professional dialogue and discipline during which both the primary researcher and the participating teacher applied their best professional practices to compartmentalize their roles as de facto employees of the research site from specialized roles as primary researcher and assisting research participant throughout the process. By means of this ongoing dialogue, the primary researcher believes the third and fourth limitations described above were effectively addressed during the present study.

Contribution of Research

The primary researcher asserts the findings of the present study illustrate a key issue of sound pedagogical practice. Specifically, given the present study quantifiably demonstrates despite the lack of statistically significant differences between traditional didactic pedagogy and inquiry-based learning pedagogy, students nonetheless manifest significantly more positive feelings about inquiry-based learning compared to traditional didactic learning processes. The study thus raises two compelling questions requiring further consideration: (a) what makes the difference in students' perceptions of the learning environment; and (b) is the perceptual difference rooted solely in Bandura's (1971, 1977) social interaction concept, or could it be what actually affects student perception is neither the learning process itself nor the socialization inherent in inquiry-based learning pedagogy, but rather something the students are observing in their teacher; Those two questions may require new theoretical frameworks as the following discussion will illuminate.

In light of the findings of the present study, in conjunction with many years of professional practice as a classroom teacher and trainer of other teachers, the researcher asserts the key component of student perception in the classroom is the teacher's belief system as reflected in the teacher's pedagogical practice as well as the teacher's personal and professional demeanor. Given the present findings demonstrating learning outcomes are not measurably different for two disparate pedagogies while student perceptions are measurably divergent, the researcher postulates the classroom environment created by the teacher and the teacher's demeanor reflected to the students actually makes the difference in students' response to the learning process. The researcher hereby introduces the postulate Reflected Learning Theory, asserting students are more powerfully affected by what they see reflected in teachers' behavior rather than the pedagogy employed.

Reflected Learning Theory

Reflected Learning Theory is rooted in three venerable education theories:

1. Reflected Learning Theory is informed by Bandura's (1971, 1977) seminal Social Learning Theory which fundamentally asserted social interaction and human observation as the driving force of the institutional learning process.

2. Reflected Learning Theory is illuminated by Piaget's (1926, 1954) concept of cognitive and lingual child development, in which he asserted the relational, interactive nature of the learning child's higher-order thinking processes.

3. Reflected Learning Theory is aligned with Dewey's (1933) postulate human beings learn by constructing a framework of concepts which have been gleaned from interaction with others, particularly knowledgeable mentors who are deeply vested in the learner's achievement of a complete conceptual framework.

Reflected Learning Theory builds upon the theoretical framework by adding a key characteristic: teacher belief systems. As noted previously, Brickman et al. (2009) emphasized the necessity of assisting students' transition from a role of receiver of knowledge to being a creator of knowledge. However, in order for the teacher to become a facilitator of student creation of knowledge, the teacher must strongly believe they are empowered as a professional conductor of the learning process. When the teacher feels empowered rather than entitled, that empowerment is reflected upon and within their students as a real sense of self-efficacy. When the teacher reflects positive beliefs and feelings about the learning process, Reflected Learning Theory postulates students will reflect those positive characteristics back to the teacher. Reflected Learning Theory therefore asserts students become what is modeled by teachers. Reflecting joy in the learning process empowers the teacher to create psycho-cognitive space in which students can advance understanding. Reflected Learning Theory asserts through this interactive process the teacher's empowerment in turn empowers their students to succeed.

Reflected Learning Theory may also explain how it is possible for a teacher to consistently receive negative performance evaluations indicating technical deficiency, while consistently receiving positive student evaluations indicating high levels of student satisfaction in their classes. The present study strongly implies the difference in the pedagogical approach is not what affects the student learning process, but rather what students perceive in their teacher. When positive behaviors are expressed by the teacher, Reflected Learning Theory asserts students will enthusiastically engage the learning process. When negative behaviors such as disinterest or disapproval are expressed by the teacher, Reflected Learning Theory predicts lower student engagement and satisfaction levels. The relationship between teacher affect and student response is therefore asserted to portend the greatest impact on student learning outcomes.

Reflected Learning Theory fundamentally predicts when the teacher creates a classroom environment characterized by joyful, positive co-learning students will respond to the authenticity of the teacher’s mentoring presence with commensurate joy and passion in the learning process. In such a classroom environment, student satisfaction is asserted to be a direct function of the teacher's positive belief system and genuine pleasure in the student's achievement of positive learning outcomes. Reflected Learning Theory thus seeks to engender and support authentic co-learning (Brookfield, 1995). In this context, the teacher is not merely dispensing academic content. Rather, they are teaching their students by modeling joyful life-long learning, and in doing so they are empowering their students to create a new and powerful identity as life-long learners.

Finally, Reflected Learning Theory asserts if what the teacher reflects is what their students developmentally need, the teacher can be assured they will have an incremental positive impact on each student's long-term social and academic development.

Ethics and Reflexivity

The primary researcher was a senior administrator at research site, which could have resulted in perceived coercion, adversely affecting willingness of the teacher or students to participate. Further, as a full-time administrator at research site, primary researcher could have struggled with need to compartmentalize the study separate from professional responsibilities. Both concerns were mitigated by strong support from other senior administrators, who not only encouraged the present study and communicated positively within the research site, but who also encouraged the primary researcher to communicate fully and transparently with all parents and students to create the highest level of trust and positive reception. The primary researcher was also a seasoned CITI-licensed quantitative researcher with substantial prior research experience.

Issues of conflict of interest or task compartmentalization could have arisen given participating teacher was a long-time friend of primary researcher whose families were well-known to one another. Further, research procedures were conducted during the last two weeks of the school year, typically a highly stressful period for teachers and administrators. Relational concerns were mitigated by primary researcher's effort to engage teacher in planning research procedures well in advance of actual processes including discussing test curriculum, mutual classroom roles, and theoretical objectives. Including teacher in planning processes ensured study was conducted with maximum trust and professional integrity, and minimum stress.

Two transformative learning experiences were achieved by primary researcher:

1. It was deeply thought provoking and transformative to realize outcomes were substantially divergent from researcher's expectations. The primary researcher realized educators must take great care not to assume education community hype is truly valid without rigorously testing appropriate data. As a professional administrator and education consultant, primary researcher was further provoked to reflect on whether past professional advice offered to educators was overly simplistic or naïve, lacking a research-based framework.

2. Consciousness toward theory informed, research based counsel and training was the most profound achievement of the present study and will guide the primary researcher throughout the remainder of her career in education.

Future Research Concepts

One of the key limitations of the study was research site was a private, religious academy primarily accessible to white, upper middle class professional families. Given the transportable design of the research schema, it would be of great value to conduct multiple iterations of the study in a variety of demographic environments to ascertain whether results are consistent across various socio-economic, socio-cultural, or regional environments.

Another key concern of the present study was the limitation of small sample sizes. Sample size can be addressed when future iterations are conducted by aggregating multiple data sets into a meta-analysis, increasing sample size for statistical purposes. It would be of great value to conduct iterations of the research schema employing larger student samples. One advantage of conducting large-sample iterations is to ascertain whether large sample results are statistically significantly different from small-sample-findings.

Finally, great care was taken in the present study to employ appropriate curriculum at an appropriate grade level affording the primary researcher with relatively clear and distinct measures of outcome differences. Future iterations of the research schema should employ a variety of curricula in multiple grades, to ascertain whether findings of the study are consistent across various types of classroom content and student grade levels.

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Appendix A

Student Survey

Student Survey

(To be completed by students via Survey Monkey at the conclusion of their unit of study)

SATISFACTION

1. On a scale of 1 to 10, did this unit about ________ make you feel good about what you were learning?

1 2 3 4 5 6 7 8 9 10

Did not feel good — Felt really good

2. On a scale of 1 to 10, do you think you can use what you learned in your life?

1 2 3 4 5 6 7 8 9 10

Cannot use — Definitely will use

3. On a scale of 1 to 10, do you think this was the best way to learn about _______?

1 2 3 4 5 6 7 8 9 10

Not the best way — Definitely the best way

UNDERSTANDING

4. On a scale of 1 to 10, do you feel that you know more about ___________ than you did before this unit of study?

1 2 3 4 5 6 7 8 9 10

Don't know any more than I did — I know lots more

5. On a scale of 1 to 10, do you feel like you could tell someone else what you learned about ________________ during this unit of study?

1 2 3 4 5 6 7 8 9 10

I don't think so — Sure I could tell anybody what I learned

6. On a scale of 1 to 10, do you feel like you will remember what you learned about ____________ from this unit of study?

1 2 3 4 5 6 7 8 9 10

I won't remember anything — I will never forget what I learned

ENGAGEMENT

7. On a scale of 1 to 10, did this unit keep you interested for an entire week?

1 2 3 4 5 6 7 8 9 10

Bored out of my mind — Most interesting lesson ever

8. On a scale of 1 to 10, did you feel that during this unit you wanted to hear what your teacher was going to teach you next?

1 2 3 4 5 6 7 8 9 10

Really wished she would shut up — Really wanted her to tell me more

9. On a scale of 1 to 10, did this lesson make you feel like _______ is a topic worth learning about?

1 2 3 4 5 6 7 8 9 10

A complete waste of time — I want to know more about __________

10. On a scale of 1 to 10, did you feel happy during this unit?

1 2 3 4 5 6 7 8 9 10

I felt really unhappy — Most happy I have ever been during a lesson

Appendix B

Unit Pretest and Posttest Scores Data by Sample Group

Unit Pretest and Posttest Scores Data By Sample Group

Sample 1			Sample 2		
ID#	Pretest	Posttest	ID #	Pretest	Posttest
1	57.50	65.00	16	37.50	57.50
2	62.50	65.00	17	40.00	47.50
3	57.50	50.00	18	77.50	75.00
4	47.50	67.50	19	35.00	37.50
5	40.00	60.00	20	32.50	45.00
6	47.50	45.00	21	32.50	55.00
7	50.00	50.00	22	37.50	52.50
8	27.50	35.00	23	62.50	55.00
9	42.50	57.50	24	42.50	40.00
10	35.00	32.50	25	30.00	30.00
11		A±	26	37.50	35.00
12	42.50	47.50	27		A±
13	57.50	65.00	28	65.00	67.50
14	37.50	37.50	29	52.50	55.00
15	45.00	57.50	30	40.00	60.00
M	46.43	51.88	*M*	44.46	60.83
	11.73% Increase			36.81% Increase	

Note. ±A = Participant did not complete the Posttest.

Appendix C

Survey Score Data By Sample Group

Survey Score Data By Sample Group

Sample 1

ID#	1.FG?	2.CU?	3.BW?	4.KM?	5.TO?	6.WR?	7.SI?	8.WN?	9.WL?	10.FH?	*M*
1	2	1	1	3	1	1	1	1	1	1	1.30
2	5	3	2	7	6	7	4	4	5	6	4.90
3	4	5	3	5	4	3	2	2	3	3	3.40
4	8	9	10	8	9	8	10	8	9	8	8.70
5	3	1	3	1	1	1	4	5	2	5	2.60
6	7	10	6	9	8	7	10	6	9	8	8.00
7	8	8	9	9	7	9	9	10	9	8	8.60
8	3	2	7	1	4	4	1	5	5	5	3.70
9	6	4	8	9	7	6	4	7	5	6	6.20
10	5	3	2	6	3	8	10	10	10	8	6.50
12	7	5	8	10	8	6	9	10	8	7	7.80
13	2	4	2	5	3	1	1	2	1	10	3.10
14	6	5	6	7	4	7	4	5	7	6	5.70
15	8	5	3	8	7	7	5	6	9	8	6.60
M	5.29	4.64	5.00	6.29	5.14	5.36	5.29	5.79	5.93	6.36	

Note. *M* = Mean.

Sample 2

ID#	1.FG?	2.CU?	3.BW?	4.KM?	5.TO?	6.WR?	7.SI?	8.WN?	9.WL?	10.FH?	*M*
16	6	2	8	9	10	3	7	5	5	7	6.20
17	7	6	5	6	7	9	8	6	8	7	6.90
18	6	6	3	5	8	6	5	7	5	7	5.80
19	5	3	5	7	2	2	3	2	5	4	3.80
20	4	2	3	3	5	3	6	5	2	4	3.70
21	1	1	1	8	1	1	1	1	1	1	1.70
22	1	3	1	2	2	1	3	2	3	2	2.00
23	7	6	10	7	5	5	3	7	10	7	6.70
24	4	7	5	4	4	5	9	10	10	9	6.70
25	10	8	7	1	10	6	9	9	10	9	7.90
26	3	5	1	1	10	4	3	3	1	5	3.60
28	3	4	1	4	5	6	2	3	1	1	3.00
29	9	8	10	6	10	10	10	5	9	7	8.40
30	4	2	3	4	1	7	6	4	4	7	4.20
M	5.00	4.50	4.50	4.79	5.71	4.86	5.36	4.93	5.29	5.50	

*Note***.** FG? = Feel Good?; CU? = Can use?; BW? = Best way?; KM? = Know more; TO? = Tell others?; WR? = Will remember?; SI? = Stay interested?; WN? = Wanted next?; WL? = Worth learning?; FH? = Felt happy?. *M* = Mean. Taken from Appendix A: Student survey, C.G. Ziemer, 2013.

Appendix D

SPSS Output for Testing of Hypothesis 1

RQ_1-H_1: Independent Samples *t*-Test Comparing Pretest-Posttest Scores Between Sample Groups

Group Statistics

	CLASS	N	Mean	Std. Deviation	Std. Error Mean
PRETEST	1	14	46.4286	9.93799	2.65604
	2	14	44.4643	14.35064	3.83537
POSTTEST	1	14	52.5000	11.84840	3.16662
	2	14	50.8929	12.61894	3.37255

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PRE-TEST	Equal variances assumed	1.756	.197	.421	26	.677	1.96429	4.66526	-7.62529	11.55386
	Equal variances not assumed			.421	23.137	.678	1.96429	4.66526	-7.68336	11.61193
POST-TEST	Equal variances assumed	.000	.983	.347	26	.731	1.60714	4.62619	-7.90212	11.11640
	Equal variances not assumed			.347	25.897	.731	1.60714	4.62619	-7.90395	11.11824

RQ_1-H_1: One-Sample *t*-Test Results Comparing Pretest-Posttest Scores Within Sample Groups (Test Value= 100)

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CLASS1PRE	14	46.4286	9.93799	2.65604
CLASS1POST	14	52.5000	11.84840	3.16662

One-Sample Test

	Test Value = 100					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CLASS1PRE	-20.170	13	.000	-53.57143	-59.3095	-47.8334
CLASS1POST	-15.000	13	.000	-47.50000	-54.3411	-40.6589

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CLASS2PRE	14	44.4643	14.35064	3.83537
CLASS2POST	14	50.8929	12.61894	3.37255

One-Sample Test

	Test Value = 100					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CLASS2PRE	-14.480	13	.000	-55.53571	-63.8215	-47.2499
CLASS2POST	-14.561	13	.000	-49.10714	-56.3931	-41.8212

Appendix E

SPSS Output for Testing of Hypothesis 2

RQ_2-H_2: Matched Pairs *t*-Test Comparing Change in Test Scores in Samples 1& 2 Across All Survey Questions

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	CLASS1PRE	46.4286	14	9.93799	2.65604
	CLASS1POST	52.5000	14	11.84840	3.16662
Pair 2	CLASS2PRE	44.4643	14	14.35064	3.83537
	CLASS2POST	50.8929	14	12.61894	3.37255

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	CLASS1PRE & CLASS1POST	14	.710	.004
Pair 2	CLASS2PRE & CLASS2POST	14	.741	.002

Paired Samples Test

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	CLASS1PRE - CLASS1POST	-6.07143	8.47589	2.26528	-10.96526	-1.17760	-2.680	13	.019
Pair 2	CLASS2PRE - CLASS2POST	-6.42857	9.84077	2.63006	-12.11046	-.74668	-2.444	13	.030

Group Statistics: RQ_2-H_2: Matched Pairs *t*-Test

	CLASS	N	Mean	Std. Deviation	Std. Error Mean
Q1	1	14	5.29	2.199	.588
	2	14	5.00	2.689	.719
Q2	1	14	4.64	2.763	.738
	2	14	4.50	2.378	.635
Q3	1	14	5.00	3.038	.812
	2	14	4.50	3.228	.863
Q4	1	14	6.29	2.946	.787
	2	14	4.79	2.517	.673
Q5	1	14	5.14	2.627	.702
	2	14	5.71	3.474	.928
Q6	1	14	5.36	2.818	.753
	2	14	4.86	2.742	.733
Q7	1	14	5.29	3.583	.957
	2	14	5.36	2.925	.782
Q8	1	14	5.79	2.992	.800
	2	14	4.93	2.674	.715
Q9	1	14	5.93	3.222	.861
	2	14	5.29	3.518	.940
Q10	1	14	6.36	2.341	.626
	2	14	5.50	2.710	.724

Matched Pairs *t*-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Q1	Equal variances assumed	.335	.567	.308	26	.761	.286	.928	-1.623	2.194
	Equal variances not assumed			.308	25.014	.761	.286	.928	-1.626	2.198
Q2	Equal variances assumed	.000	1.000	.147	26	.885	.143	.974	-1.860	2.145
	Equal variances not assumed			.147	25.436	.885	.143	.974	-1.862	2.147

Q3	Equal variances assumed	.017	.897	.422	26	.676	.500	1.185	-1.935	2.935
	Equal variances not assumed			.422	25.905	.677	.500	1.185	-1.936	2.936
Q4	Equal variances assumed	.329	.571	1.448	26	.159	1.500	1.036	-.629	3.629
	Equal variances not assumed			1.448	25.380	.160	1.500	1.036	-.631	3.631
Q5	Equal variances assumed	1.624	.214	-.491	26	.628	-.571	1.164	-2.964	1.821
	Equal variances not assumed			-.491	24.205	.628	-.571	1.164	-2.973	1.830
Q6	Equal variances assumed	.183	.673	.476	26	.638	.500	1.051	-1.660	2.660
	Equal variances not assumed			.476	25.981	.638	.500	1.051	-1.660	2.660
Q7	Equal variances assumed	1.069	.311	-.058	26	.954	-.071	1.236	-2.612	2.469
	Equal variances not assumed			-.058	24.999	.954	-.071	1.236	-2.617	2.474
Q8	Equal variances assumed	.195	.662	.799	26	.431	.857	1.072	-1.347	3.061
	Equal variances not assumed			.799	25.678	.431	.857	1.072	-1.348	3.063
Q9	Equal variances assumed	.064	.802	.504	26	.618	.643	1.275	-1.978	3.263
	Equal variances not assumed			.504	25.802	.618	.643	1.275	-1.979	3.264
Q10	Equal variances assumed	.930	.344	.896	26	.379	.857	.957	-1.110	2.824
	Equal variances not assumed			.896	25.460	.379	.857	.957	-1.112	2.826

Appendix F

SPSS Output for Testing of Hypothesis 3

RQ$_3$-H$_3$: Pearson Correlation Comparing Posttest Scores to Post-lesson Student Survey Responses

Correlations: Sample 1

		CHANGE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
CHANGE	Pearson Correlation	1.000	.003	-.188	.209	-.183	.044	-.211	-.087	.040	-.173	.066
	Sig. (1-tailed)		.496	.260	.237	.266	.440	.235	.384	.446	.277	.411
	N	14.000	14	14	14	14	14	14	14	14	14	14
Q1	Pearson Correlation	.003	1.000	.765**	.645**	.841**	.871**	.876**	.770**	.723**	.872**	.487*
	Sig. (1-tailed)	.496		.001	.006	.000	.000	.000	.001	.002	.000	.039
	N	14	14.000	14	14	14	14	14	14	14	14	14
Q2	Pearson Correlation	-.188	.765**	1.000	.614**	.722**	.792**	.630**	.680**	.418	.645**	.533*
	Sig. (1-tailed)	.260	.001		.010	.002	.000	.008	.004	.068	.006	.025
	N	14	14	14.000	14	14	14	14	14	14	14	14
Q3	Pearson Correlation	.209	.645**	.614**	1.000	.490*	.713**	.539*	.495*	.626**	.519*	.292
	Sig. (1-tailed)	.237	.006	.010		.038	.002	.023	.036	.008	.029	.155
	N	14	14	14	14.000	14	14	14	14	14	14	14
Q4	Pearson Correlation	-.183	.841**	.722**	.490*	1.000	.839**	.747**	.662**	.575*	.675**	.519*
	Sig. (1-tailed)	.266	.000	.002	.038		.000	.001	.005	.016	.004	.028
	N	14	14	14	14	14.000	14	14	14	14	14	14
Q5	Pearson Correlation	.044	.871**	.792**	.713**	.839**	1.000	.741**	.633**	.572*	.701**	.504*
	Sig. (1-tailed)	.440	.000	.000	.002	.000		.001	.008	.016	.003	.033
	N	14	14	14	14	14	14.000	14	14	14	14	14
Q6	Pearson Correlation	-.211	.876**	.630**	.539*	.747**	.741**	1.000	.759**	.758**	.927**	.492*
	Sig. (1-tailed)	.235	.000	.008	.023	.001	.001		.001	.001	.000	.037
	N	14	14	14	14	14	14	14.000	14	14	14	14
Q7	Pearson Correlation	-.087	.770**	.680**	.495*	.662**	.633**	.759**	1.000	.846**	.855**	.537*
	Sig. (1-tailed)	.384	.001	.004	.036	.005	.008	.001		.000	.000	.024
	N	14	14	14	14	14	14	14	14.000	14	14	14

Q8	Pearson Correlation	.040	.723**	.418	.626**	.575*	.572*	.758**	.846**	1.000	.828**	.528*
	Sig. (1-tailed)	.446	.002	.068	.008	.016	.016	.001	.000		.000	.026
	N	14	14	14	14	14	14	14	14	14.000	14	14
Q9	Pearson Correlation	-.173	.872**	.645**	.519*	.675**	.701**	.927**	.855**	.828**	1.000	.544*
	Sig. (1-tailed)	.277	.000	.006	.029	.004	.003	.000	.000	.000		.022
	N	14	14	14	14	14	14	14	14	14	14.000	14
Q10	Pearson Correlation	.066	.487*	.533*	.292	.519*	.504*	.492*	.537*	.528*	.544*	1.000
	Sig. (1-tailed)	.411	.039	.025	.155	.028	.033	.037	.024	.026	.022	
	N	14	14	14	14	14	14	14	14	14	14	14.000

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

RQ_3-H_3: Pearson Correlation Comparing Posttest Scores to Post-lesson Student Survey Responses

Correlations: Sample 2

		CHANGE	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
CHANGE	Pearson Correlation	1.000	-.443	-.789**	-.315	.270	-.398	-.355	-.126	-.529*	-.490*	-.389
	Sig. (1-tailed)		.056	.000	.137	.176	.079	.106	.334	.026	.037	.084
	N	14.000	14	14	14	14	14	14	14	14	14	14
Q1	Pearson Correlation	-.443	1.000	.710**	.824**	.091	.659**	.668**	.704**	.642**	.781**	.749**
	Sig. (1-tailed)	.056		.002	.000	.379	.005	.005	.002	.007	.000	.001
	N	14	14.000	14	14	14	14	14	14	14	14	14
Q2	Pearson Correlation	-.789**	.710**	1.000	.516*	-.276	.587*	.673**	.592*	.720**	.763**	.651**
	Sig. (1-tailed)	.000	.002		.029	.169	.014	.004	.013	.002	.001	.006
	N	14	14	14.000	14	14	14	14	14	14	14	14
Q3	Pearson Correlation	-.315	.824**	.516*	1.000	.412	.446	.435	.582*	.530*	.820**	.664**
	Sig. (1-tailed)	.137	.000	.029		.072	.055	.060	.014	.026	.000	.005
	N	14	14	14	14.000	14	14	14	14	14	14	14
Q4	Pearson Correlation	.270	.091	-.276	.412	1.000	-.131	-.049	-.093	-.162	.120	-.039
	Sig. (1-tailed)	.176	.379	.169	.072		.328	.433	.376	.289	.341	.447
	N	14	14	14	14	14.000	14	14	14	14	14	14
Q5	Pearson Correlation	-.398	.659**	.587*	.446	-.131	1.000	.456	.511*	.428	.309	.498*
	Sig. (1-tailed)	.079	.005	.014	.055	.328		.051	.031	.063	.141	.035
	N	14	14	14	14	14	14.000	14	14	14	14	14
Q6	Pearson Correlation	-.355	.668**	.673**	.435	-.049	.456	1.000	.640**	.471*	.523*	.559*
	Sig. (1-tailed)	.106	.005	.004	.060	.433	.051		.007	.045	.027	.019
	N	14	14	14	14	14	14	14.000	14	14	14	14
Q7	Pearson Correlation	-.126	.704**	.592*	.582*	-.093	.511*	.640**	1.000	.712**	.700**	.801**
	Sig. (1-tailed)	.334	.002	.013	.014	.376	.031	.007		.002	.003	.000
	N	14	14	14	14	14	14	14	14.000	14	14	14

Q8	Pearson Correlation	-.529*	.642**	.720**	.530*	-.162	.428	.471*	.712**	1.000	.796**	.855**
	Sig. (1-tailed)	.026	.007	.002	.026	.289	.063	.045	.002		.000	.000
	N	14	14	14	14	14	14	14	14	14.000	14	14
Q9	Pearson Correlation	-.490*	.781**	.763**	.820**	.120	.309	.523*	.700**	.796**	1.000	.815**
	Sig. (1-tailed)	.037	.000	.001	.000	.341	.141	.027	.003	.000		.000
	N	14	14	14	14	14	14	14	14	14	14.000	14
Q10	Pearson Correlation	-.389	.749**	.651**	.664**	-.039	.498*	.559*	.801**	.855**	.815**	1.000
	Sig. (1-tailed)	.084	.001	.006	.005	.447	.035	.019	.000	.000	.000	
	N	14	14	14	14	14	14	14	14	14	14	14.000

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

Appendix G

Science Unit Objective Test for Pretest and Posttest

Name ____________________ Period ________ Date ____________

CHAPTER 8 | MOUNTAINS AND VOLCANOES

Diagnostic Test

Choose the letter of the best answer.

____ **1.** Which of the following best describes magma?
a. molten rock that flows over Earth's surface
b. solid rock at Earth's surface
c. molten rock beneath Earth's surface
d. solid rock beneath Earth's surface

____ **2.** Magma can form when
a. molten rock cools on the ocean floor
b. a sinking tectonic plate begins to melt
c. magnetic changes occur below Earth's surface
d. rock is exposed to wind, water, and air at Earth's surface

____ **3.** In the middle of tectonic plates, volcanoes may form over
a. hot spots
b. cooling centers
c. continental-continental collision zones
d. oceanic-continental collision zones

____ **4.** What happens along a subduction zone?
a. Two continental plates come together.
b. Two oceanic plates pull apart.
c. A continental plate sinks into the mantle.
d. An oceanic plate sinks into the mantle.

____ **5.** Which of these might happen along a convergent boundary?
a. Oceanic and continental plates come together.
b. Oceanic plates slide horizontally past each other.
c. Oceanic plates pull apart.
d. Continental plates pull apart.

____ **6.** What is a spreading center?
a. a place where continental plates come together
b. a place where oceanic plates pull apart
c. a place where plates move horizontally past each other
d. a place where plates move vertically past each other

Name ______________________ Period ________ Date ____________

____ 7. A transform boundary is a place where blocks of rock
a. come together
b. pull apart
c. move horizontally past each other
d. move vertically past each other

____ 8. Earth's rigid outer layer, which includes the crust and the very top of the mantle, is called the
a. outer core
b. land
c. continent
d. lithosphere

____ 9. What is a fault?
a. any opening in Earth's surface
b. a break in the lithosphere along which movement takes place
c. a boundary between two continents
d. a break in the asthenosphere along which movement takes place

____ 10. Most earthquakes and many other major geological events occur
a. along tectonic plate boundaries
b. along the shores of a continent
c. in the middle of an oceanic plate
d. in the middle of a continental plate

Name Period Date

CHAPTER 8 | MOUNTAINS AND VOLCANOES

Chapter Test A

Key Concepts

Choose the letter of the best answer. (4 points each)

____ **1.** What is one way that a folded mountain belt can form?
- **a.** Two oceanic plates spread apart.
- **b.** Two continental plates push together.
- **c.** Old volcanoes erupt and grow.
- **d.** Blocks of crust move along faults.

____ **2.** Volcanoes in folded mountain belts form when
- **a.** a continental plate moves over a hot spot
- **b.** an oceanic plate is broken by faults
- **c.** an oceanic plate partly melts as it goes into the mantle
- **d.** a continental plate crumples as it collides with another plate

____ **3.** Blocks of rock tilt when forces pull Earth's crust apart. Where are tilted blocks of rock commonly found?
- **a.** where two oceanic plates collide
- **b.** where two continental plates collide
- **c.** along subduction zones
- **d.** along ocean spreading zones

____ **4.** An opening through which lava, rocks, and gases erupt is called a
- **a.** caldera
- **b.** fumerole
- **c.** volcano
- **d.** geyser

____ **5.** A dense cloud of super-hot gases and rock fragments that races downhill from an erupting volcano is called a
- **a.** pyroclastic flow
- **b.** steam explosion
- **c.** cinder eruption
- **d.** landslide

Name Period Date

____ **6.** Most volcanoes occur
a. in the center of a continent
b. along plate boundaries
c. along fault zones
d. over hot spots

____ **7.** Scientists monitor volcanoes to
a. prevent future eruptions from occurring
b. predict when future eruptions will occur
c. prevent gases from escaping through openings in Earth's crust
d. cool the temperature of the magma rising inside the volcano

____ **8.** Which of these can be dangerous to people who live far from an erupting volcano?
a. ash clouds, because they can be carried by the wind
b. lava flows, because they can burn the ground
c. landslides, because they move very fast
d. volcanic soils, because they are very hot

____ **9.** Volcanoes can affect Earth's atmosphere by increasing
a. sunlight levels
b. acid rain
c. worldwide temperatures
d. the size of the atmosphere

____ **10.** Hot springs that erupt and send hot water shooting into the air are called
a. fumaroles
b. oceanic ridges
c. geysers
d. deep-sea vents

Name Period Date

CHAPTER 8 | MOUNTAINS AND VOLCANOES

Chapter Test B

Key Concepts

Choose the letter of the best answer. (4 points each)

____ **1.** A folded mountain belt is located far from the edge of a present-day tectonic plate boundary. This mountain belt likely formed

a. when two oceanic plates collided
b. when two continental plates collided
c. as the result of volcanic activity
d. when blocks of crust moved along faults

____ **2.** Folded mountains form at tectonic boundaries where

a. new ocean crust is formed
b. plates move away from each other
c. plates move toward each other
d. plates move horizontally past each other

____ **3.** Blocks of rock that have tilted along faults are common

a. where two oceanic plates collide
b. where two continental plates collide
c. along subduction zones
d. along ocean spreading centers

____ **4.** What is a volcano?

a. a chamber of magma deep beneath the surface
b. a mountain that forms as the result of faulting
c. an opening through which lava, rocks, and gases erupt
d. a huge crater that forms as the result of collapsing rocks

____ **5.** What makes a pyroclastic flow so dangerous?

a. its speed and its temperature
b. its temperature and its silica content
c. its speed and its cinder content
d. its temperature and its volume

Name ______________________ **Period** __________ **Date** __________

____ **6.** Volcanoes form at
a. converging boundaries and diverging boundaries only
b. hot spots and faults only
c. diverging boundaries and hot spots only
d. converging boundaries, diverging boundaries, and hot spots

____ **7.** Which of the following signs might indicate that a volcano might soon erupt?
a. increased wearing away of volcanic rocks
b. rising temperatures in volcanic lakes
c. falling temperatures in volcanic lakes
d. decreased wearing away of volcanic rocks

____ **8.** Which of these can be dangerous to people who live hundreds of kilometers from an erupting volcano?
a. volcanic ash clouds
b. lava flows
c. landslides
d. volcanic soil

____ **9.** What are some of the effects of volcanic eruptions on Earth's atmosphere?
a. an increase in the amount of sunlight that reaches Earth and a decrease in acid rain
b. a decrease in the amount of sunlight that reaches Earth and an increase in Earth's temperature
c. an increase in acid rain and an increase in Earth's temperature
d. an increase in acid rain and a decrease in Earth's temperature

____ **10.** What does a fumarole release?
a. hot, liquid water
b. steam and other gases
c. cold, liquid water
d. magma

Name ______ Period ______ Date ______

CHAPTER 8 | MOUNTAINS AND VOLCANOES

Chapter Test C

Key Concepts

Choose the letter of the best answer. (4 points each)

_____ **1.** Which of these correctly describes the order of events involved in the formation of the Himalayas?
- **a.** continental collision, subduction zone development, volcanic eruptions
- **b.** subduction zone development, volcanic eruptions, continental collision
- **c.** volcanic eruptions, continental collision, subduction zone development
- **d.** continental collision, volcanic eruptions, subduction zone development

_____ **2.** Along which type of plate boundary are folded mountains most likely to form?
- **a.** transform
- **b.** active
- **c.** convergent
- **d.** divergent

_____ **3.** Blocks of rock that have tilted along faults are common along ocean spreading centers because in these areas
- **a.** the sea floor is slowly spreading apart
- **b.** two oceanic plates are colliding and spreading out
- **c.** lava from deep sea vents slowly builds up in layers
- **d.** subduction causes lava to spread over the ocean floor

_____ **4.** Which of the following lists the rock fragments released by a volcano in order from smallest to largest?
- **a.** bombs, blocks, cinders
- **b.** cinders, bombs, ash
- **c.** blocks, ash, cinders
- **d.** ash, cinders, bombs

_____ **5.** Which of the following best describes a pyroclastic flow?
- **a.** very hot solids and gases that flow down the slopes of a volcano
- **b.** ash, cinders, and bombs that flow down the slopes of a volcano
- **c.** very hot solids and gases that collect in a magma chamber
- **d.** ash, cinders, and bombs that collect in a magma chamber

Name Period Date

____ **6.** Why are many of Earth's volcanoes found near subduction zones?
a. Subduction is caused by volcanic activity.
b. Earthquakes affect conditions that can lead to both subduction and volcanoes.
c. The subducted plate separates and allows magma to rise.
d. The sinking plate heats, partially melts, and forms magma.

____ **7.** Signs that a volcano may erupt soon include
a. decreased earthquake activity and falling temperatures of volcanic lakes
b. increased earthquake activity and rising temperatures of volcanic lakes
c. decreased earthquake activity and rising temperatures of volcanic lakes
d. increased earthquake activity and falling temperatures of volcanic lakes

____ **8.** Which of these poses the greatest danger to people who live within a few kilometers of an active shield volcano?
a. lava flows
b. thick ash falls
c. violent eruptions
d. tsunamis

____ **9.** How do volcanoes contribute to acid rain?
a. They spray out liquid sulfuric acid during pyroclastic flows.
b. Their intense heat releases acid from the lava.
c. They release carbon dioxide gas, which is naturally acidic and poisonous.
d. They release sulfur dioxide and other gases that mix with water and form acids.

____ **10.** Fumaroles are different from hot springs because fumaroles
a. are heated by magma lying underneath Earth's surface
b. release only steam and other gases instead of water
c. are hot year-round instead of only in summer
d. may be found over volcanic hot spots