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Teachers' practices and perceptions concerning the implementation of inquiry-based instruction in middle school science

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TEACHERS' PRACTICES AND PERCEPTIONS CONCERNING THE IMPLEMENTATION OF INQUIRY-BASED INSTRUCTION IN MIDDLE SCHOOL SCIENCE

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APPROVAL OF DISSERTATION

We, the faculty supervising the work of **Jill Wood**, affirm that the dissertation, *Teachers' Practices and Perceptions Concerning the Implementation of Inquiry-Based Instruction in Middle School Science*, meets the high academic standards for original scholarship and creative work established by the EdD Program in **Curriculum and Instruction** and the College of Education and Professional Development. This work also conforms to the editorial standards of our discipline and the Graduate College of Marshall University. With our signatures, we approve the manuscript for publication.

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DEDICATION

This dissertation is dedicated to my grandfather and grandmother, Pasquale and Joann Belcastro. His passion for learning and her constant reminders of the importance of education gave me the drive to pursue my doctorate. I'm thankful for their guidance throughout my life.

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ABSTRACT

The purpose of this research study was to investigate West Virginia middle school science teachers' perceptions regarding inquiry-based instruction. Teacher efficacy level, extent of use, and supports and obstacles in regard to inquiry-based instruction were considered. In addition, demographic relationships were explored in comparison with efficacy level and extent of use in regard to inquiry-based instruction. Demographics included number of preps taught, years of science teaching experience, class size, class time, planning time, professional development opportunities attended, and exposure to inquiry-based instruction in education science course work. West Virginia middle school science teacher perceptions of this study were measured using a 6-point Likert scale and included three qualitative questions in regard to supports, obstacles, and additional comments concerning inquiry-based instruction. Fifty-seven West Virginia middle school science teachers from 26 schools across six counties were included in this study. The data revealed the majority of respondents felt comfortable using inquiry-based instruction, recognized its effectiveness in teaching students science, and perceived inquiry-based instruction to be more effective than lecture or text-based instruction. Conversely, many respondents feel they were not adequately trained in inquiry-based instruction in their science education course work and are not comfortable creating inquiry-based instruction that aligns with state standards. Furthermore, many respondents disagreed that the West Virginia Next Generation Science Content Standards and Objectives are effective teacher guidelines for creating inquiry-based instruction. Administration, colleagues, and student level of enjoyment and engagement were agreed as forms of support for inquiry-based instruction. Lack of laboratory supplies, lack of funding, and limited class and planning time were perceived as obstacles in the use of inquiry-based instruction. Further research on equitable funding for

middle school science classrooms, across West Virginia, could benefit student achievement in science and eliminate many barriers middle school teachers face in the use of inquiry-based instruction. Additionally, the creation of a state-level professional development program that addresses the use of inquiry-based instruction that aligns with West Virginia Next Generation Science Content Standards and Objectives could greatly benefit teacher efficacy levels in inquiry-based instruction, especially for new and uncertified middle school science teachers.

CHAPTER 1

INTRODUCTION

Science is defined as “knowledge or a system of knowledge covering general truths, or the operation of general laws especially as obtained and tested through scientific method” (Science, n.d.). Inquiry techniques are advantageous and effective when teaching science due to science concepts being explorative. Scientific inquiry includes studying both the natural world and conducting scientific investigations to answer questions using evidence that is gathered in a systematic way (National Science Teachers Association, 2004). Previously, West Virginia science content standards and objectives included a requirement of fifty percent hands-on inquiry-based instruction and learning (West Virginia Board of Education, 2009). Under the current *Next Generation Content Standards and Objectives for Science in West Virginia Schools*, Policy 2520.3C, the fifty percent requirement wording has been removed, but there is still an emphasis on inquiry-based learning in all science classrooms K-12 (West Virginia Board of Education, 2015).

The United States report from the Committee on STEM education stressed the importance that “jobs of the future are STEM jobs” (National Science & Technology Council, 2013, p. vi). The belief that STEM education is critical to the future global economy is due to either perceived or real shortages in current and future career options in addition to lagging other countries in achievement scores (Organisation for Economic Co-operation and Development, 2013). Currently, “STEM education in U.S. schools leaves a great deal to be desired” (Hoachlander, 2014/2015, p. 74). Research shows that nations with high test scores have well-developed curricula that focuses on “21st century skills including inquiry processes, problem-solving, critical thinking, creativity, and innovation as well as strong focus on disciplinary knowledge" (English, 2016, p.3). National goals for science education in the United States include increasing the number of students that choose to pursue science degrees, increasing the number of women and minority groups in science professions, and increasing scientific literacy among all students (National Research Council, 2012; President's Council of Advisors on Science & Technology, 2010).

Inquiry-based instruction has been prevalent in research since 1909 when Dewey advocated that science students should experience science rather than passively receive science content (Jeanpierre, 2006). More than 50 years later, Schwab and Brandwein (1966) reasserted that the main goal of science teaching was that "students might have opportunities to learn how scientific knowledge is generated and to participate in the practices of science" (Lakin & Wallace, 2015, p. 139). Current thought on science education in the United States is that inquiry-based instruction is the "key strategy to effective science teaching" (National Research Council, 1996, p. 36).

Since its origin in science-based teaching, inquiry has had many meanings according to the literature. The confusion of what inquiry actually is or what it looks like in the classroom is evident in the literature. Regardless, inquiry "has a decades-long and persistent history as the central word used to characterize good science teaching and learning" (Anderson, 2002, p.1). Inquiry-based instruction should include at least the following methods: allow students to be curious and ask questions, develop hypotheses and explanations, conduct investigations, make observations and gather evidence, formulate explanations and communicate their findings (National Research Council, 1998). The act of teaching in an inquiry-based manner includes both hands-on activities and an understanding of how scientists study the natural world (National Research Council, 1996).

Recent efforts by policy makers and science educators across the nation have reaffirmed the importance that inquiry-based instruction be consistently used in science classrooms. Inquiry-based instruction differs significantly from the lecture and memorization method that dominated science classrooms in the beginning of the twentieth century (Lawson, 1995). Both the *Next Generation Science Standards* (NGSS) and the *Framework for K-12 Science Education* documents emphasize inquiry-based learning as a critical component of science (National Research Council, 2012; National Research Council, 2013). Using inquiry-based instruction in the science classroom is beneficial due to both increased student motivation to learn science and student achievement in science (Crawford, 2012; Edelson, 1998). Both of these benefits potentially will boost student enrollment in advanced STEM degrees and future STEM careers.

Evidence of inquiry-based instruction being a recommended strategy is easily found in Policy 2520.3C *The Next Generation of Content Standards and Objectives for Science in West Virginia Schools* (West Virginia Board of Education, 2015). The policy states, "by its very nature, science embodies the doing of science" and the current policy "describes students engaging in those practices" (West Virginia Board of Education, 2015, p. iv). These statements clarify that doing science is integral throughout grades kindergarten through twelve to ensure that each student furthers their "education, careers, and general welfare" (West Virginia Board of Education, 2015, p.iv). This topic is of significance due to both national and international pressure to improve the quality of science, technology, engineering and mathematics or STEM education (Johnson, Peters-Burton & Moore, 2015). Although this study will focus specifically on science education practices, research centered around STEM education is applicable.

According to an analysis of the *National Science Education Standards* (NSES), scientific inquiry, inquiry learning and inquiry-based instruction all have different meanings (Anderson, 2002). This study will focus upon inquiry-based instructional methods which include “inquiry into authentic questions generated from student experiences,” learning activities that help students “develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world, and as a means of assessment” (Anderson, 2002, pp. 2-3). The actual meaning of science teaching in an inquiry-based manner will be clarified for the study.

Statement of the Problem

An ideal science classroom should use standards-based teaching and include a variety of components that support inquiry-based learning (SciMathMN, 1997). Students should experience goal-oriented “active science” by using materials and lab equipment in a safe and adequate facility (SciMathMN, 1997, para. 2). An observation into an ideal classroom will reveal students asking questions about real-world problems and using scientific concepts and inquiry-based problem-solving to develop solutions. A variety of laboratory equipment and technology should be available to students to enhance the learning environment (SciMathMN, 1997). Teachers will be moving around the room observing and listening to students during inquiries and facilitating the lessons rather than lecturing from the front of the room (Capitelli, Hooper, Rankin, Austin & Caven, 2016).

Students should be engaged in scientific inquiry and understand that the process of inquiry is as important as the results. The standards should guide the learning and assessments should be varied in type. The assessments should evaluate the student’s depth of understanding of scientific inquiry and concepts. All students, regardless of sex, race, or ability level, should learn science and the teacher should be confident and competent in teaching “hands-on, minds-on” science (SciMathMN, 1997, para. 2). Research suggests that teachers are “clearly aware of the need to teach using inquiry-based methods" but are "uncertain how to bridge awareness to competent practice" (Marshall & Smart, 2013, p. 132). Often teachers that are ill-equipped to teach science using inquiry use "short, often disconnected, entertaining activities" instead of more time-consuming, content-laden investigations (Marshall & Smart, 2013, p.133). True inquiry-based instruction will fuse content, the process, and results in authentic scientific inquiry (Windschitl, 2008).

Class size is another factor in science education that may hinder inquiry-based, hands-on learning. According to the National Science Teachers Association (NSTA) (2007) science teachers are the responsible party for reporting any safety issues, including overcrowding of the classroom, to both school and district officials. Science classrooms containing more than 24 students cannot be adequately supervised by one teacher and have a higher likelihood of accidents due to both overcrowding and inadequate personal workspace (West, Westerlund, Stephenson & Nelson, 2005). Increased class sizes also hinder hands-on learning because often there are not enough materials or equipment for all students to participate in the lab experience. Inadequate materials and equipment often lead to teacher demonstrations which may dampen student excitement and engagement. The lack of supplies is significant due to inquiry-based instruction potentially leading to student motivation to enter higher-level science programs and potentially science careers (Crawford, 2012).

Teachers' understanding of what inquiry-based instruction means and being able to use it proficiently in the classroom is critical to the future of science education in the United States. Many studies suggest that both in-service and pre-service teachers have developed "incorrect conceptions of inquiry-based teaching" and the problem persists across the nation's schools (Lakin & Wallace, 2015, p.144). Inquiry, as a word, has varied definitions and may cause the confusion that many teachers feel when asked if they are using inquiry-based instruction methods. Inquiry has had many names throughout history such as hands-on science, hands-on/minds-on science, and various inquiry subtypes (Lumpe & Oliver, 1991). The process of teaching science using inquiry techniques "is complex" and many teachers have a "poor understanding of inquiry and are unable to implement" these methods in their classrooms (Chowdhary, Liu, Yerrick, Smith & Grant, 2014, p. 865). This study will seek to clarify what inquiry-based instruction means and looks like in a middle school classroom in West Virginia.

Purpose of the Study

The purpose of this study is to determine whether West Virginia sixth, seventh, and eighth grade science teachers are implementing hands-on, inquiry-based instruction methods. The participants are from schools located in six counties in West Virginia. Twenty-six middle schools and their science teachers will be included in the study. Teachers will also be asked about the support they receive for the use of inquiry-based instruction techniques and barriers that impede this style of instruction. Additionally, demographic variables and their relationship to teacher perceptions and practices concerning inquiry-based instruction will be compared among respondents.

Rationale of the Study

This study proposed to research West Virginia middle school science teachers' perceptions of their use of inquiry-based instruction methods. Demographic data such as grade level taught, years of experience, areas of certification, class size, extent of use of inquiry-based instruction, class time, planning time, and inquiry-based instruction training will be collected. In addition, barriers and support of inquiry-based instruction will be investigated. Relationships between levels of support or obstacles and use of inquiry-based instruction will be investigated.

This study will benefit multiple groups including science teachers in West Virginia, higher education programs that educate pre-service science teachers, and state departments of education that create and provide professional development opportunities.

Additional relevance can be found by investigating current literature on science standards across the nation. Inquiry-based instruction and learning in science classrooms remains a dominant topic in the literature due to the projections of future STEM-based careers and the link between student motivation and inquiry methods (Crawford, 2012; National Research Council, 1996; National Research Council, 2012).

Significance of the Study

This study is significant as the results from the findings of this study may be valuable to school leaders, science teachers, university education program directors, and policy makers at the state, county, and local school levels. These groups are attempting to close the achievement gap in science throughout the nation's schools and thus increase the number of students that enter STEM careers in the future. An underlying issue that adds to the significance of this study is the pervasive problem that many science teachers know that inquiry-based instruction is the most effective way to instruct science students yet are not using this method of instruction. Therefore, results from this study may be useful in creating an action plan that leads to a transformation of teaching techniques used in West Virginia science classrooms.

Research Questions

A review of grade sixth, seventh, and eighth *West Virginia Next Generation Content Standards and Objectives for Science in West Virginia Schools* and a review of inquiry-based instruction and learning literature guided the development and formation of independent variables. Variables that were identified include teacher efficacy levels teaching science in an inquiry-based instructional style, the supports that allow inquiry-based instruction, and the obstacles that impede inquiry-based instruction and how these variables relate to class-time spent on inquiry-based instruction. In addition, the study explored the effect, if any, of demographic variables on the teachers' perceptions on inquiry-based instruction. Teachers' perception was the dependent variable that all results were analyzed against.

1. What are teachers' perceptions of their efficacy level in inquiry-based instruction methods?
2. What are teachers' perceptions of their extent of use of inquiry-based instruction methods?
3. What are teachers' perceptions of the supports that allow their use of inquiry-based instruction?
4. What are teachers' perceptions of the obstacles that impede their use of inquiry-based instruction?
5. What are the differences in teachers' perceptions of efficacy level in inquiry-based instruction due to demographic factors such as number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size.
6. What are the differences in teachers' perceptions of the use of inquiry-based instruction due to demographic factors such as number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size.

Operational Definition of Terms

Inquiry: a way to study the natural world and conduct scientific investigations to answer questions using evidence that is gathered in a systematic way.

Teacher Demographics: Demographics refer to the study of human populations in a statistical manner. Demographic variables have been identified on the survey in reference to science teachers' number of preps, area of certification, years of classroom experience, class size, class time, planning time, inquiry-based instruction training, and extent of use. (Questions 1-8)

- **Number of Preps:** The response of teachers to the demographic item regarding middle school science grade level(s) that they currently teach. (Question #1)
- **Years of Experience:** The response of teachers to the demographic item regarding their years of experience as a classroom middle school science teacher. (Question #2)
- **Area of Certification:** The response of teachers to the demographic item regarding their area of certification or licensure according to the West Virginia Department of Education. (Question #3)
- **Class Size:** The response of teachers to the demographic items regarding their middle school science class sizes in terms of number of students. (Question #4)
- **Class Time:** The response of teachers to the demographic items regarding the length of their middle school science classes in terms of time. (Question #5)
- **Planning Time:** The response of teachers to the demographic items regarding the length of their planning time and number of planning times they have per school day. (Question #6)
- **Inquiry-Based Instruction Training:** The response of teachers to the demographic items regarding their learning of inquiry-based instructional methods during their college coursework and professional development opportunities. (Questions #7 & 8)

Extent of Use: The response of teachers to the demographic items regarding their extent of use of inquiry-based instruction methods in their middle school science classes. (Question #9)

Efficacy Level: the level of comfort or confidence that science teachers have in their personal ability to teach science effectively using inquiry-based instructional methods (Questions #10-18)

Supports: objects or people that improve and increase inquiry-based teaching (Questions #19-33 & 34)

Barriers: objects, people, or dilemmas that impede inquiry-based teaching (Questions #19-33 & 35)

Inquiry-based instruction: methods that allow students to be curious and ask questions, develop hypotheses and explanations, conduct investigations, make observations and gather evidence, and formulate and communicate their findings. (Question #36)

Assumptions of the Study

This study assumes that West Virginia middle school science teachers understand the current meaning of inquiry-based science instruction. The study also assumes that all sixth, seventh, and eighth grade science teachers understand the current West Virginia *Next Generation Science Content Standards and Objectives* and their instruction is guided by these standards (West Virginia Board of Education, 2015). The researcher also assumes that all teachers that receive the survey will respond to the survey and answer honestly.

Limitations and Delimitations

The method of data collection will be a paper survey that is either hand-delivered or mailed to school administrators or school designees of the 26 participating middle schools in six West Virginia counties. Topics that will be addressed include methods of support that teachers receive such as funding, donations, community and parent support, adequate facilities and equipment, professional development opportunities, and manageable class sizes. Barriers that will be addressed include a lack of funding, teachers without a stationary classroom, overcrowded classes, lack of knowledge or experience teaching inquiry-based instructional methods, pressure to cover content rather than obtain a depth of knowledge, and teachers without a laboratory classroom. The number of surveys that are returned will be a limitation beyond the researcher's control.

The focus of this study is on West Virginia middle school science teachers' perceptions on the use of inquiry-based instruction in the science classroom. Only sixth, seventh, and eighth grade science teachers located in six counties of West Virginia will be surveyed.

CHAPTER 2

REVIEW OF THE LITERATURE

How instructors should best teach science has been the focus of multiple studies in the past. The variety of teaching styles and techniques that can be used in science classes are of interest for many reasons. Student engagement, another factor, may be a key to unlock student success. Inquiry-based instruction has been linked to both increased student engagement and academic success (Glasson, 1989). Although there have been some conflicting findings, it is generally agreed upon that inquiry-based instruction is beneficial to science students (Anderson, 1982). In fact, according to DeBoer (1991), “If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be inquiry” (p.206).

Who were the leaders in advancing inquiry-based instruction? What is inquiry-based instruction? Defining inquiry itself is a challenge due to multiple beliefs of what inquiry really means. What does a science classroom look like that employs inquiry-based instruction? What are the current science standards in West Virginia in terms of inquiry-based instruction? How were the current West Virginia standards developed? What supports are available to science teachers that allow them to conduct inquiry-based instruction? What barriers prevent inquiry-based instruction to become a reality in United States science classrooms? Are teachers comfortable and confident in their knowledge of inquiry to use this strategy as their primary method of instruction? This review of the literature attempts to examine and illustrate the findings of the questions posed above.

History of Inquiry

John Dewey (1910) is first credited for acknowledging the importance of scientific inquiry in public education. Dewey (1910) advocated that students should experience rather than receive scientific knowledge. Schwab (1962) echoed Dewey in saying that inquiry is a fluid process that involves “uncertainty and failure” but results in students gaining knowledge of the subject matter (p.5). Evidence shows that little has changed in public education after Dewey’s proclamation that there was too much emphasis on obtaining content knowledge without using that knowledge for scientific inquiry. Inquiry became a common component of the science education community after World War II due to the belief that the United States’ scientific abilities were directly linked to both military and economic success (Abrams, Southerland, & Evans, 2008). At that time, Bruner, and subsequently Schwab, began initiatives to further the thought that inquiry was central to successful science education. Bruner (1962) said it is essential that students learn to organize their thoughts “in such a way as to make what” they learn “usable and meaningful” (p.20). Schwab (1962) reaffirmed that science teaching placed too much emphasis on accumulation of facts rather than science as a way of thinking. The results of this movement towards inquiry are evident again in the 1970s National Science Foundation’s curriculum recommendations (National Science Board, 2000).

The true beginnings of inquiry-based instruction can also be credited to the work of Jean Piaget, Lev Vygotsky, and David Ausubel (Cakir, 2008). These theorists described the nature of learning and teaching and are credited with developing the philosophy of learning known as Constructivism (Cakir, 2008). Constructivism advocates that students should be participating in hands-on activities to increase both student motivation and engagement. Both student motivation and engagement are critical to the success of inquiry-based instruction. The Constructivist approach also emphasizes that student knowledge grows through active thinking, engagement, and social interaction (Mayer, 2004). All of these factors align with inquiry-based instruction.

The Constructivist influence on science curriculum development is evident from literature and committees that were developed during the 1970s. During the 1970s, many committees were formed with the sole purpose of advancing science curriculum in public education. The *Biological Sciences Curriculum Study* (BSCS), the *Physical Sciences Study Committee* (PSSC), the *Science Curriculum Improvement Study* (SCIS), and the *Elementary Science Study* (ESS) all focused on making inquiry-based instruction the primary method of teaching and learning science. In the 1980s, *A Nation at Risk* was published and again recommended that the teaching of science should focus upon inquiry-based instruction (United States, 1983). Throughout the 1990s, many proponents of inquiry-based instruction also echoed the past recommendations that inquiry was an essential component to effective science education (National Research Council, 1996; National Research Council, 1998). The past is still reflected in the present, with the current *Next Generation Science Standards*, NGSS, explicitly explaining the importance of using inquiry-based instruction in the classroom for student success and engagement (National Research Council, 2013). With decades of support and research, why is inquiry-based instruction so misunderstood and underused in science education within the United States? Perhaps, the difficulty of defining what inquiry means, what it looks like in action, and the complexity of teaching in this manner have limited its use as an instructional technique in classrooms across America.

Efficacy of Inquiry-Based Instruction

Efficacy is defined as the ability to produce a desired or intended result. In this sense, is inquiry-based instruction able to produce students that are proficient in science, interested in science, and choosing career paths related to the sciences? As educators, efficacy in science education is related to all of the above parameters. Inquiry-based instruction has been the primary recommended mode of instruction from science educational experts for more than one hundred years. Thus, researching inquiry-based instructions' efficacy is essential to this study. Bredderman (1983) and Shymanksky, Kyle and Alport (1983) conducted syntheses of inquiry-based instruction and its efficacy. Both syntheses revealed that teachers using inquiry-based instruction increased student learning, student performance, student process skills, and improved student attitudes toward science. Wise and Okey (1983) also found a positive relationship between inquiry-based instruction and cognitive outcomes. Minner, Levy, and Century (2010) found that out of 138 inquiry-based instruction research studies, occurring between 1984 and 2002, that more than 51% had positive influence on both student learning and retention. Some experts believe inquiry-based instruction to be overestimated in its ability to increase student achievement, but many studies suggest otherwise (Hodson, 1990; Hodson, 1996). Chang and Mao (1999) researched inquiry-based instruction versus a traditional teacher-centered lecture approach and found that students involved in an inquiry-based setting increased their standardized test scores. McCarthy (2005) found that learning disabled middle school science students instructed using inquiry performed significantly better on textbook based achievement tests, hands-on assessment, and a short answer test than learning disabled students taught in a teacher-centered lecture fashion.

Minner et al., (2010) found a "clear and consistent trend" that inquiry-based instruction, specifically the investigation cycle, is "associated with improved student content learning, especially learning scientific concepts" (p. 20). This synthesis also revealed that "hands-on experiences with scientific or natural phenomena" increased student learning (Minner et al., 2010, p. 20). These findings align with the constructivist learning theories that advocate that students should construct their own knowledge to effectively retain and comprehend it. Schroeder, Scott, Tolson, Huang, and Lee (2007) completed a meta-analysis on inquiry-based instruction versus traditional teaching methods and found similar results. Schroeder et al. (2007) defined inquiry strategies as using student-centered instruction that is less prescribed, less teacher-directed, and incorporates full inquiry. They compared these types of inquiry studies to traditional teaching methods such as lecture-based instruction and the use of the scientific method, or TSM. Schroeder et al. (2007) found that inquiry had a statistically significant positive influence on student achievement.

Inquiry-based instruction has been found to improve middle school students' skill levels in laboratory activities, graphing ability, and ability to analyze data (Mattheis & Nakayama, 1988). Numerous studies have reiterated that inquiry-based instruction increases student achievement (Glasson, 1989), scientific literacy and process skills (Lindberg, 1990), vocabulary and concept knowledge (Lloyd & Contreras, 1987), critical thinking skills (Narode, 1987). Perhaps even more interesting and important, inquiry-based instruction has been found to improve achievement in our most fragile students: language-minority students, deaf students, and learning-disabled students (Chira, 1990; Rodriguez & Bethel, 1983; Rosebery, Warren & Conant, 1990). Additional studies indicate that inquiry-based instruction helps to improve learning in a variety of student groups, including low-socioeconomic status students and minority groups (Heywood & Heywood, 1992; Huveyda, NEED, 1994; Scruggs & Mastropieri, 1993). All indications within the review of literature and current recommendations from the National Research Council (2013) that inquiry-based instruction be the primary method of science instruction further solidify that this topic is relevant to research further.

Inquiry-Based Instruction

As evidenced in decades of science education research, the focus in science classrooms should be on the use of inquiry-based instruction. Authentic inquiry requires much more than following the linear steps of The Scientific Method, or TSM. Critical components of inquiry-based instruction include allowing students to become proficient in reviewing scientific literature, redesigning experiments when necessary, making connections to related scientific theories, providing relevant explanations of unobservable phenomena, and using models to understand information (Abrams, Southerland, & Evans, 2008). Students should become comfortable enough with the inquiry process that they can apply it to solving real world problems. In addition, students should participate in inquiry-based activities and be proficient in the processes and obtain the skills necessary to understand the natural world. Inquiry used to increase student content knowledge is a lesser understood entity within the overall discussion. Conflicting results, from several studies, exist on whether inquiry-based instruction actually improves student academic success (Chang & Mao, 1999; Gibson, 1998; Russel & French, 2001).

Frequently, throughout the literature idealized versions of science classrooms are mentioned. Science classrooms should be clean, bright, clutter-free, organized and spacious. An average American can easily imagine what a science classroom should look like. Images of lab benches, microscopes, greenhouses, Bunsen burners, and dissection stations may come to mind. But to go further in depth, what is actually occurring in an inquiry-based science classroom? Beyond the materials and space that are needed for safe experimentation, what types of discussions, modeling, and creating are happening? Essentially, what does inquiry look like in a typical science classroom? Beyond the physical aspects of a desirable science classroom, what should be occurring in a class that is instructed using inquiry-based methods?

Ideally, inquiry should prevail as the primary method of instruction in science classes. Teachers and their students should have zero-time constraints, materials and equipment should be abundant, and focus should not lie on students mastering a standardized test. Teachers should be facilitators of students that are investigating the natural world around them through varied methods. Science class should be modeled upon the work being conducted in scientific laboratories and the students' actions should mimic that of scientists. Unfortunately, the reality of American classrooms is that they are not idealized. In classrooms across the United States, school days are structured, class times are limited, class sizes are large, teacher and student confidence and comfort levels with inquiry vary widely among teachers, funding may be lacking, and teaching to a standardized test is rampant (Abrams, Southerland, & Evans, 2008). Variables such as the above make changing science classroom instruction to inquiry-based a very difficult and daunting task. The lack of a simple and consistent definition for inquiry after more than fifty years of its use in the literature is of concern.

Despite its faults and difficulties, inquiry-based instruction is still touted as being the superior method of instruction to improve students' academic success and levels of engagement. Inquiry-based instruction is a complex and time-consuming method of instruction. For this reason, many science teachers have fallen prey to the hands-on, simple inquiry, and task-oriented method of scientific instruction. Although, hands-on activities and pre-made labs do keep students occupied, often they have no tie-in to the true nature of scientific investigation and inquiry. Without a link to content knowledge and real-world problems, students often have difficulty connecting these simple inquiry activities to scientific concepts. Knowledge retention, understanding, and real-world relevance are likely to suffer without connections to the subject matter (Banilower, Smith, Weiss, & Pasley, 2006; Roth & Garnier, 2007). Proponents of inquiry-based instruction and learning do not advocate hands-on activities just for the sake of completing a project (National Research Council, 2013). Inquiry-based instruction includes much more than students completing a pre-designed and highly prescribed laboratory or activity. According to Windschitl, Thompson, and Braaten (2007), reversing the current mode of American science education which consists mainly of "activity without understanding" will be a massive undertaking that science educators must make a priority (p. 942).

Inquiry has been defined in multiple, often conflicting, manners. It includes terms and processes such as hands-on learning, discovery approach to science, and using the scientific method to develop skills in science (Collins, 1986; DeBoer, 1991; Rakow, 1986). One consistency throughout the literature is that inquiry-based instruction should engage students in the "investigative nature of science" (Haury, 1993). Dewey (1964) is credited for stating that "by taking a hand in the making of knowledge, by transferring guess and opinion into the belief authorized by inquiry" students are able to truly learn science (p. 188). Inquiry is also defined as "active and operative" by Boisvert (1998) and requires that teachers continually reflect and grow more aware of the process for it to be a successful method of teaching (p.38). Abrams, Southerland, and Evans (2008) define classroom inquiry as "activity that echoes some subset of the practices of authentic science" (p. 29). A reoccurring theme in the literature, is that many science teachers do not fully understand what using inquiry-based instruction in the classroom entails. This lack of clarity is problematic, and some believe that the inconsistent definition of inquiry may be to blame (Anderson, 2002; Abd-El-Khalick et al., 2004; National Research Council, 2012).

Inquiry-Based Instruction in the Classroom

Inquiry-based instruction in the classroom is multifaceted. Examples from the literature include student observations, development of questions, experimental design, data analysis, sharing results, discussion, arguments, and linking singular concepts to a broader meaning (Abrams, Southerland, & Evans, 2008). In addition, the component of scientific literacy being directly linked to inquiry is important to note. *The Biological Sciences Curriculum Study* (1993) identified four levels of scientific literacy: nominal, functional, structural, and multidimensional. As student ability in scientific literacy grows their ability to conduct inquiry grows in a parallel fashion. Teacher behavior is also a component of how inquiry-based instruction works in a class setting. Teachers must be willing to give students more control of their learning, become flexible in lesson planning, give regular and constructive feedback, answer and ask students appropriate questions, and be confident in their students' inquiry abilities (Abrams, Southerland, & Evans, 2008). Teachers are not necessarily doing less work but taking on different roles in an inquiry-based classroom. Teachers will become facilitators, guides, motivators and mimic the role of scientists.

Studies indicate that science teachers rarely use full-inquiry as their primary instructional method, although it is the recommended form of instruction by the *National Science Education Standards* (NSES) (Chinn & Malhotra, 2002; Jeanpierre, 2006). The complex undertaking of using inquiry-based instruction has been studied from various perspectives. Studies have investigated teacher perceptions of their use of inquiry, the effectiveness of inquiry in regard to student success, and what teachers believe using inquiry-based instruction consists of (Anderson, 2002; Ertepinar & Geban, 1996; Jeanpierre, 2006). The majority of K-12 educators use either "partial inquiry" or "simple inquiry tasks" rather than full inquiry (Jeanpierre, 2006, p.64).

Further analysis of Jeanpierre's (2006) survey results indicated that many teachers believe they are using full-inquiry while the reality differs significantly. Teacher perceptions of inquiry use, as revealed in Jeanpierre's (2006) survey provide evidence that many science teachers may be confused or lack knowledge of what using inquiry-based instruction in the classroom actually means. Windschitl, Thompson, and Braaten (2007) go further and state that using The Scientific Method, TSM, may be to blame for teacher confusion on what inquiry actually means. The belief that TSM oversimplifies the true nature of inquiry and has led to generations of students, at the K-12 and collegiate levels, without adequate inquiry skills are not new (Bauer, 1992; Hodson, 1996; Rudolph, 2005).

Four specific problems have been identified for strictly using TSM as the main instructional practice in science classrooms. First, students are provided with questions to study which lead to "uninformed and contentless" investigations (Windschitl, Thompson, & Braaten, 2007, p. 946). Roth and Garnier (2007) found particular problems with the TSM in American science classrooms and stated that "almost one-third of the lessons narrowly focused students' attention on performing activities with no attempt on the teachers' part to relate these activities to science ideas" (p. 20). Secondly, TSM only focuses on controlled experimentation, with one variable being manipulated, and one result being expected. While controlled laboratory experimentation is part of inquiry, many other methods are used in science to test hypotheses. With TSM, there is little to no focus on discussion, research, modeling, and evidence gathering that is necessary when completing true scientific inquiry (Windschitl, Thompson, & Braaten, 2007).

Third, TSM does not require that students have a fundamental understanding of science concepts, but rather allows students to make observations of phenomena they do not fully understand. Scientific inquiry and explanation is “not only about patterns in observable relationships” but “why a phenomenon happens in a particular way” (Windschitl, Thompson & Braaten, 2007, p. 947). Lastly, TSM allows students, and perhaps teachers, to believe that scientific inquiry is a linear process. This oversimplified method may be favored because it is easy to explain to students, well-defined, and “highly-prescribed” (Windschitl, Thompson & Braaten, 2007, p. 947). In modern science classrooms, that may be overcrowded and limited on time, it would be easy for a teacher to use TSM solely to fill the need and requirements for hands-on science. TSM guided experiments are not true scientific inquiries which is troubling since inquiry-based instruction is the recommended instructional practice for student success (National Research Council, 2012). Overuse of TSM in K-12 classrooms has allowed science to become “a procedure, but not a way of thinking” (Windschitl, Thompson, & Braaten, 2007, p. 947).

According to the research, most beginning science teachers have a skewed view of what scientific inquiry actually entails. A study revealed that teachers understand the process of TSM but have a limited view of the nature of scientific inquiry (Windschitl, 2003; Windschitl, 2004). Overall, most science teachers participating in the study were found to completely disregard or not understand true inquiry methods such as researching and developing “arguments and claims, alternative explanations, the development of models of natural phenomena” but rather focused on testing hypotheses to solely reach pre-determined cause-and-effect relationships (Windschitl, Thompson & Braaten, 2007, p. 948).

Questions still exist one hundred years after Dewey described inquiry methods as to what using inquiry-based instruction actually looks like in the science classroom. The National Science Education Standards have identified six practices that are essential for using inquiry-based instruction in the classroom (National Research Council, 1996). According to the NSES, students using inquiry should “ask questions about the natural world, …plan investigations”, collect, organize, and analyze data, use critical thinking skills and logic to determine whether evidence supports scientific explanations, use observations and content knowledge to create evidence-based explanations, and communicate results (Jeanpierre, 2006, p. 58). According to Abrams, Southerland, and Evans (2007) there are five categories in a classroom that intersect to determine what inquiry will look and be like. The categories include logistics, socio-cultural factors, cognitive ability and literacy of the students, nature of the content, and goals of the activity. When these five factors are understood and analyzed the teacher can make decisions on the level of inquiry, simple or full, that is necessary to achieve the goal of student understanding

Inquiry is thought to invoke four primary notions in the curricular aspect of teacher’s lives: seeing, relational knowing, mindful embodiment, and assessment as inquiry (Macintyre Latta, Buck, Leslie-Pelecky, & Carpenter, 2007). In Latin, inquiry means ‘to seek.’ For teachers, this means seeing what is occurring beneath the surface of the classroom during inquiry-based learning. Specifically, this type of seeing requires attention to many facets of teaching and learning (Macintyre Latta et al., 2007). Dewey (1964) referred to this type of seeing as inner attention and allows students, teachers, and subject matter to become linked, cohesive, and relevant to life. Seeing of this type allows teachers to focus on students’ learning rather than worrying that students are noisy, moving around the classroom, or off task. Students’ inner thoughts about learning become relevant in an inquiry-based classroom which potentially could lead to meaningful, lasting knowledge (Macintyre Latta et al., 2007).

Relational knowing allows teachers and students to revise and deepen their understandings of subject matter (Macintyre Latta et al., 2007). Relational knowing has been shown to be critical and fundamental to student learning (Dewey, 1964; Jardine, Clifford & Friesen, 2003; Noddings, 2004). The process accounts for students creating their own thoughts, or "sense-making," and also a collective sense-making as a class (Macintyre Latta et al., 2007, p. 29). Inquiry-based classrooms should make relational knowledge a key component as it allows for shared knowledge that mimics true scientific discovery that is universally shared. In addition, relational knowledge further personifies the nature of science as it allows for, and promotes, differing perspectives. Students are encouraged to create their own ideas and solutions to problems, which often results in multiple perspectives being investigated (Macintyre Latta et al., 2007). Celebrating differences and discussing various solutions to problems encourages students to listen and respect varying viewpoints. Appreciating diversity is a skill and mindset that benefits all students beyond the classroom.

Mindful embodiment embraces that there are no true boundaries regarding subject-matter in an inquiry-based classroom. There should be continual cross-curricular learning opportunities, as well as learning, that involves emotions, dialogue, and reciprocity (Macintyre Latta et al., 2007). Dewey (1938) says teachers must be effective facilitators of learning by encouraging students to make connections between their own lives and learning. Assessment of inquiry is essential to student learning due to the current issue of teaching to the test. Teachers are ever aware of the pressures for students to reach proficiency on state-mandated standardized tests. Scores on standardized assessments are ever-growing in their importance and can be linked to issues such as school funding, teacher pay, and school performance grades. Thus, it is critical that teachers learn to create meaningful methods of assessing student knowledge when employing the strategy of inquiry-based instruction.

Inquiry is also identified as “participatory in nature, vigilant to the question(s) in which the inquiry originates, organic in form, and always turning back on self” (Macintyre Latta et al., 2007, p. 35). Inquiry can be said to be centered around three goals in science education: how we learn about the process of conducting inquiry, how we perform inquiry, and how inquiry leads to knowledge of scientific concepts (Abrams, Sutherland, & Evans, 2008). A commonly referenced model of inquiry originated from Schwab and is echoed by Colburn (2000). Schwab (1962) describes inquiry as existing on four levels, based primarily upon level of teacher guidance. Level 0 inquiry consists of total teacher guidance from formulating the questions being asked, the method of data collection used, and the interpretation of the results. Level 0 would be comparable to simple inquiry, TSM, or as Colburn (2000) refers to it, as structured inquiry. Level 1 and 2 inquiries are still primarily teacher guided in terms of question generation but allow students more flexibility and freedom in their choice of data collection methods and interpretation of results. Colburn (2000) refers to this as guided inquiry. Lastly, Level 3 inquiry places all learning responsibility on students and is known as open inquiry (Colburn, 2000).

Model-based inquiry is an additional facet to the growing definition of what type of inquiry is best-suited for the classroom. The goal is for students to understand why they are completing activities and “to develop defensible explanations of the way the natural world works” (Windschitl, Thompson & Braaten, 2007, p. 955). As with other variations of inquiry-based instruction, model-based instruction begins with teachers setting parameters of what will be studied. Once guidelines are provided to students, students engage in four types of activities: organizing what they know and what they want to find out, generating testable hypotheses, seeking evidence, and constructing an argument (Windschitl, Thompson, & Braaten, 2007). The level of teacher guidance and control should vary according to student age and ability. Although this method may seem prescribed, as with TSM, it involves constant revisiting and revising of thoughts as new data becomes available to the students through experimentation and research. Windschitl, Thompson, and Braaten (2007) recognize that for model-based inquiry to be effective both teachers and students must be proficient in the subject matter for sense to be made during inquiry activities.

Current Instructional Practices

Current science instruction in the United States was studied and analyzed through the *National Survey of Science & Mathematics Education* (NSSME). The survey revealed many inconsistencies, nationwide, among student groups, communities, and grade levels. Disparity in science education exists in rural areas of the country and in schools with the majority of the student population belonging to minority groups (Weiss, Pasley, Smith, Banilower, & Heck, 2003). It is unusual to note, out of the three primary levels of schooling, elementary, middle, and high, that middle school science lessons were found to be weaker, in terms of inquiry level and connectedness to the subject matter (Weiss et al., 2003).

United States science instruction has been found to be lacking in the following areas: content matter, ideas about the natural world, and linkages to real-world issues. Corcoran & Gerry (2011) say it is the American way to teach science through meaningless hands-on activities without an understanding of science concepts and ideas. Banilower et al. (2013) find that most science teachers in the United States spend the majority of their class time explaining science concepts in a teacher-led lecture format. Overall, in the United States science classes often consist of hands-on activities without reasoning and projects are not directly linked to scientific ideas (National Academies Science, Engineering, &Medicine, 2015). The *Framework of K-12 Science Education*, and the state-created *Next Generation Science Standards*, recommend that science teachers must be ready and willing to change how they teach science in the United States. It is the belief that most United States teachers will have to alter the way they teach in order to effectively incorporate the new recommendations set forth by the NGSS and the Framework.

Next Generation Science Standards

The term nature of science (NOS) has been a commonly featured aspect of content standards in the United States. NOS "blends insights and expertise from the philosophy, history, sociology, and psychology of science resulting" in a definition of what science is, how we do science, and how scientists interact in a community (McComas & Nouri, 2016, p.556). The following are considered key aspects of NOS that are recommended to be included in all science education curriculum:

1. Scientific knowledge is not entirely objective
2. Scientists use creativity
3. Scientific knowledge is tentative but durable
4. Scientific knowledge is socially and culturally embedded
5. Laws and theories are distinct kinds of knowledge
6. Scientific knowledge is empirically based
7. There is no universal stepwise scientific method
8. There is a distinction between observations and inferences
9. Science cannot answer all questions (and is therefore limited in its scope)
10. Cooperation and collaboration are part of the development of scientific knowledge
11. There is a distinction between science and technology
12. Experiments have a role in science (McComas & Nouri, 2016, p.556-557)

Although the importance of including NOS in national science standards was highly recommended, the reality is that science content standards in the United States were highly variable in terms of both robustness and inclusion of NOS over the past century (McComas, Lee & Sweeney, 2009). Due to the United States governments' stance on public education being a local entity, it is easily understood why the science standards varied from state to state. To combat this issue, in 2009, the Carnegie Corporation commissioned Achieve, Incorporated, a nonpartisan and nonprofit educational reform organization to lead states to develop new standards based on the *Framework of K-12 Science Education* (National Research Council, 2012). The need for these standards arose from the high variability of science standards across the nation and the fact that United States students were performing far below other nations in the area of science and mathematics (Next Generation Science Standards, 2016).

Specifically, United States students were ranked 23rd in science out of 65 *Organisation for Economic Co-operation and Development* (OECD) education systems on the 2012 *Program for International Student Assessment* (PISA) (Next Generation Science Standards, 2016). Additionally, more than one third of United States eighth graders scored below the basic level on the 2011 NAEP Science assessment (Next Generation Science Standards, 2016). In 2012, 69% of graduating high school students that took the ACT failed to meet readiness benchmark levels in science (Next Generation Science Standards, 2016). These statistics are especially troubling since there has been a call for more STEM careers and students entering STEM college programs. STEM careers are critical for further economic growth in the United States. For all of these reasons, a decision to create and implement the NGSS across the nation arose.

More recent guidelines have been formulated under the *Next Generation Science Standards*, or NGSS (National Research Council, 2013) and via the *Framework of K-12 Science*

Education (National Research Council, 2013). The Framework developers were mainly scientists interested in the education system of the United States. The development of the NGSS was a multi-state effort to develop robust and inclusive science standards. Twenty-six states, the National Science Teachers Association, the American Association for the Advancement of Science, the National Research Council, and Achieve were heavily involved in the development of the standards. As of November 2017, nineteen states along with the District of Columbia have formally adopted the *Next Generation Science Standards* (NGSS) (2009).

The goal of the Framework was to provide a blueprint for developing NGSS. NGSS differ from previous standards in that they acknowledge students need not only science skills but knowledge of scientific concepts in order to investigate the natural and man-made world (National Research Council, 2012). Of particular interest is the National Research Council (2013) intentionally replaces the word inquiry with the word practices due to the evidence inquiry itself is misunderstood and difficult to define. According to the National Research Council (2013, p. 3), the NGSS include eight methods and practices that indicate effective use of inquiry in order to understand scientific phenomena. The eight practices include:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Another significant difference, from previously developed science standards, is the requirement for three dimensions to be present in all high-quality science lessons. NGSS includes science and engineering practices, crosscutting concepts, and core disciplinary ideas essential to high-level inquiry-based instruction and learning (National Research Council, 2013). At first glance, it may seem that the Framework, and thus NGSS, lack any emphasis on the nature of science (NOS). The odd placement of the nature of science within other categories found throughout the standards has made some believe that there is a lack of emphasis on this category. The newly revised NGSS actually include four main dimensions: content, cross-cutting concepts, science and engineering practices, and the nature of science (McComas & Nouri, 2016).

The developmental process of writing the NGSS was a two-pronged approach. Step one consisted of "getting the science right" (Next Generation Science Standards, 2016). The NRC began this process through the development of the *Framework for K-12 Science Education*. The committee for development consisted of eighteen individuals that included practicing scientists, cognitive scientists, science education researchers, and science education standards and policy experts (Next Generation Science Standards, 2016). The committee was divided into design teams for the areas of physical sciences, life sciences, earth/space sciences, and engineering. The first draft of the Framework was released in 2010 and a final draft was released on July 19, 2011. The second step was managed by Achieve, Incorporated. In cooperation with twenty-six LEAD states, the NGSS were written and developed by forty members. The goal was to produce standards for K-12 science students that would prepare them for college and careers. The NGSS underwent multiple review processes and two public drafts before their final completion in April 2013. After the final draft was released in 2013, tentatively adopting states then had a chance to analyze, debate, modify, accept, and reject some of the recommendations made in the national version. The NGSS document is historic for it offers a universal tool to direct curriculum development, guide teacher education programs, and influence design of standards assessment on a national level. (McComas & Nouri, 2016).

West Virginia is not considered to have formally adopted the *Next Generation Science Standards* due to changes and omissions by the West Virginia Board of Education (WVBE) and the West Virginia Legislature (Quinn, 2016). West Virginia's Board of Education found issue with one standard concerning human contribution to the current problem of global warming. The WVBE decided to change the language to suggest that human beings' contributions to global warming was just conjecture rather than scientific fact. In addition, the legislature and the West Virginia Department of Education changed the format of their science standards and chose to remove clarification statements and information concerning the three-dimensional learning aspect that is at the crux of the NGSS (Quinn, 2016). The standards that West Virginia released are named Next Generation Content Standards and Objectives (NGCSO) (West Virginia Board of Education, 2015). Despite these differences, the NGCSO do imitate the NGSS in content and West Virginia teachers can find clarification statements and detailed information concerning the three dimensions of learning via the NGSS website (Next Generation Science Standards, 2016).

Through West Virginia Board of Education (WVBE) policy 2520.3C, the current standards for science became effective on July 1, 2016 (West Virginia Board of Education, 2015). Policy 2520.3C is organized around 2 components: 1) learning standards and 2) instructional objectives. Learning standards are stated to be "broad descriptions of what all students must know and be able to do at the conclusion of the instructional sequence" (West Virginia Board of Education, 2015, p. 3). The standards address science content, engineering design, and science literacy. The instructional objectives guide planning and help teachers to determine what “strategies, resources, and assessments” are best suited to allow students to gain knowledge, skills, practices, and attitudes that will allow them to master the standards (West Virginia Board of Education, 2015, p. 3).

This research study is limited to West Virginia middle school science teachers, so only programmatic levels 6-8 will be addressed specifically in terms of the content that supports the use of inquiry-based instruction found within the standards and objectives of WVBE Policy 2520.3C. Currently, in West Virginia middle schools, science is taught in an integrated fashion, meaning physical, life, and earth/space sciences topics are taught throughout each grade level. This review of the standards will attempt to find common themes and language within WVBE Policy 2520.3C that addresses the need for inquiry-based instruction to meet science standards and objectives for West Virginia middle school students.

For each grade level, a summary statement appears above the standards and provides details about broad topics that are to be addressed during the instructional period. Sixth grade topics include weather & climate, space systems, waves & electromagnetic radiation, matter & energy in organisms and ecosystems, interdependent relationships in ecosystems, and human interactions (West Virginia Board of Education, 2015). Immediately following the topics, the policy states that “the objectives blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge across the science disciplines” (West Virginia Board of Education, 2015, p.13). In addition, the policy states that the objectives focus on scientific practices that include model development and use, data analysis and interpretation, information obtainment, evaluation, and communication, and the creation and engagement in argumentation developed from scientific evidence (West Virginia Board of

Education, 2015). Lastly, the policy explains that placed throughout the objectives are "engineering, technology, and the application of science" practices that are critical to allow science students to "define problems…design solutions…engage in active inquiries, investigations, and hands-on activities…and develop and demonstrate conceptual understandings and research and laboratory skills" (West Virginia Board of Education, 2015, p. 13). It is apparent that West Virginia's *Next Generation Science Standards and Objectives* recognize the importance of inquiry-based instruction throughout the grade levels as recommended by both the National Research Council (2013) and the *Next Generation Science Standards* (2016).

When each standard, topic, and objective are further analyzed, the language that promotes inquiry-based instruction and learning becomes even more apparent. For example, in the sixth grade Life Sciences Content in Policy 2520.3C, the following language concerning student learning is found: "construct an explanation, evaluate design solutions, construct a scientific explanation, develop a model, analyze and interpret data, and construct an argument" (West Virginia Board of Education, 2015, p.13). Each of the seven individual standards provided under the Life Sciences Content area include language that promotes and requires the use of inquiry-based instruction and learning to reach student mastery. The inclusion of such inquiry-based language throughout the standards continues for each topic and grade level that follows. Additional inquiry-based instructional language is found throughout the sixth, seventh, and eighth grade science standards for West Virginia middle school. The language includes students being able to: "support claims, collect data, ask questions to clarify evidence, conduct investigations, provide evidence, use arguments supported by evidence, gather and synthesize information, construct and interpret data displays, plan an investigation, ask questions about data, evaluate designs, construct a scientific explanation based on evidence, apply scientific principles to design models, gather and make sense of information, make predictions, and develop real-world solutions" (WVBE, 2015). This brief review of the *Next Generation Science Content Standards and Objectives for West Virginia Schools* provides evidence that inquiring into West Virginia middle school teacher's perceptions on their use of inquiry-based instruction is pertinent and relevant. It is essential that teachers make the transition from a traditional teacher-led lecture instruction style to an inquiry-based instruction style to ensure that West Virginia students are college and career ready.

Support and Barriers to Inquiry-Based Instruction

As stated previously, in the review of the literature, inquiry-based instruction is the preferred and recommended form of instruction to promote student achievement, engagement, and motivation. Standards have been developed and adopted by many states that uphold the notion that inquiry is essential to student success in the sciences from kindergarten through twelfth grade. It is important to review and understand what supports and barriers current teachers have in terms of implementing inquiry-based instruction in science classrooms. A review of previous findings from both surveys and research concerning teacher perceptions on the use of inquiry-based instruction revealed a generalized compilation of typical supports and barriers that should be discussed.

Upon a review of literature that focuses on teacher's use of inquiry-based instruction in science classrooms, common themes appeared throughout the literature in terms of barriers and supports. The topics that seem to have influence on teachers' uses of inquiry are time, resources, professional development opportunities, number and type of concepts being taught, the need to teach to a standardized assessment, teacher beliefs about the best way to teach science, and teacher confidence and comfort level in science concepts (Gejda & LaRocco, 2006). All of the above topics can be interpreted from both sides of the lens: barrier or support in terms of the use of inquiry-based instruction. For example, the topic of time may be viewed as a support for a science teacher instructing a biology class on a block schedule that allocates ninety minutes per day, whereas another biology teacher may state that time is a barrier if they are teaching on a period schedule and only have forty-five minutes allocated per day. The review of these supports and barriers implies that these topics could have varying meaning for teachers in different schools.

Time is often mentioned in research surrounding the use of inquiry-based instruction (Louden, 1997; Welch, Klopfer, Aikenhead, & Robinson, 1981) Often times, teachers say they do not have enough time to properly use full-inquiry in their classroom because their allotted class time is too short, they have too many concepts to cover before the end of the year, or using inquiry is too time-consuming to adequately prepare for. Local and state educational leaders should look to National Research Council's (2013) Framework recommendations to realize the importance of providing science teachers adequate time to incorporate inquiry-based instruction into science education. It is essential that time does not take precedence over providing quality science instruction for West Virginia students.

Resource availability, lab equipment, and essentially money to buy these and other perishable supplies are also a commonly mentioned item that influences teachers' abilities to conduct inquiry-based instruction. Many other issues can be tied into this general topic such as adequate class space, traveling teachers, large class sizes, and structural issues such as lab benches, sinks, chemical hoods, and even technology. Without adequate materials and equipment teachers will have a difficult time integrating inquiry-based instruction into their classroom (Banilower et al., 2013). Class size may seem to be a different issue, but it can be directly linked to adequate number of class sets of laboratory materials and the physical space needed to safely conduct hands-on activities.

Professional development opportunities available to science teachers is an area that has been researched extensively. There are multiple recent studies that link sustained professional development opportunities to an increase in the use of inquiry-based instruction, cultural changes at the school level, and a shift in teachers' beliefs about what is the best way to teach students (Chowdhary et al., 2014; Herrington, Bancroft, Edwards & Schairer, 2016; Lakin & Wallace, 2015; Lebak, 2015; Marshall, Horton, Igo & Switzer, 2009; Marshall & Smart, 2013). This aspect of support to teachers attempting to use inquiry-based instruction has been extensively reviewed in light of the NGSS and its recommendations for inquiry-based instruction. As revealed in the literature, sustained professional development is one of the most essential supports science teachers can have in terms of assisting them to change their method of instruction and perhaps even change their beliefs in what science teaching should look like.

Number of, and types, of topics and concepts also appear within the literature as potential supports and barriers teachers face when teaching science in an inquiry-based fashion (Marlow & Stevens, 1999). The current pressure that teachers face concerning standardized test scores in the United States may lead to many science teachers feeling the need to cover as many topics as possible (DiBiase & McDonald, 2015). This type of thinking often leads to a glazing over of science concepts and leads to many students never learning scientific concepts at a depth necessary for true mastery. From a differing viewpoint, some topics or subjects may seem more suitable for inquiry-based instruction and learning as they are more well-suited for laboratory activities and conjecture.

Teacher beliefs and school culture can also be viewed as a support or barrier to teaching in an inquiry-based method. Many teachers were taught in a fashion that valued lecture and memorization of facts over true inquiry. Personal experiences, such as the way one receives an education, can mold and shape personal beliefs for many students as they grow up, become college educated, and lastly become teachers. The sense that it was good enough for me so that is how I will teach mentality has unfortunately had a lasting effect on science instruction in America (Adofo, 2017; National Research Council, 2013). The goal to move forward in the United States to a method of inquiry-based instruction must be accompanied with recommendations and advice on ways to address these issues that are limiting the change. Some supports that may assist in this change of teacher belief rigidity are providing mentoring for teachers, adequate time for colleague collaboration, administrative support for a cultural change in science classrooms, adequate professional development activities that assist teachers in learning more about inquiry, and state-based standards training opportunities (Gejda & LaRocco, 2006; Marshall & Smart, 2013).

Teacher comfort level, or confidence, in both inquiry-based instruction and scientific concepts is an additional piece to this puzzle. Research shows that the less confident teachers are concerning both inquiry-based instruction and their subject matter, the less likely they are to engage in the use of inquiry in their classrooms (Dolan & Grady, 2010). The National Research Council (2013) Framework recognizes this issue and calls on teacher preparation programs to increase the exposure to inquiry-based education at the collegiate level. Teacher confidence in content knowledge is essential to effective instruction and student learning regardless of the subject being taught (Marzano, 2001). Currently, many teachers in West Virginia are teaching subjects they are not fully certified in. It is essential that state legislatures discontinue the degradation of teaching requirements, for licensure and certification, so that universities that prepare science teachers can continue to provide much needed instruction in areas such as classroom management and special education, both of which can be linked to success in using inquiry-based instruction (Mascil, 2014.)

Lastly, administrative support of the change to using inquiry-based instruction in science classrooms has been found to play a large role in reform (Anderson, 1995). Johnson (2006) found that non-supportive administration was one of the top three reasons teachers identified for not using more inquiry-based instruction in the science classroom. Additionally, teacher leaders can have a positive impact on helping teachers switch from traditional instructional methods to an inquiry-based approach. Administrators and district leaders could support science teachers in this manner by allocating time for science teachers to be mentored, to collaborate with their colleagues and teacher leaders, and to attend professional development conferences to obtain the adequate knowledge and skills they need to use inquiry-based instruction in their classrooms.

CHAPTER 3

METHODOLOGY

Introduction

Chapter three provides an overview of the methods used for gathering data. The population, participants, research instrument, procedures for data collection, and data analysis are described. This research study's aim is to determine middle school science teachers' perceptions, from six West Virginia counties, on their use of inquiry-based instruction in their classrooms.

Research Design

This research study is based on quantitative data collection. The dependent variable in this study is teacher perception. The independent variables are teacher efficacy levels using inquiry-based instruction, supports and obstacles that teachers may experience when using inquiry-based instruction, and the extent of class-time spent on inquiry-based instruction. In addition, the study will explore the effect of demographic variables on teachers' perceptions of their use of inquiry-based instruction.

Population and Participants

The population of this study is West Virginia middle school science teachers. The participants are approximately 80 middle school science teachers that are employed as 6th, 7th, or 8th grade science teachers in a total of 26 schools located in six West Virginia counties. To establish approval to conduct both the pilot study and the research study, the student researcher emailed a letter of explanation to appropriate county designees and school administrators (Appendix B). The researcher supplied a consent letter and a paper survey by either visiting the schools or mailing the surveys to a county or school designee (Appendix C & D). Each school administrator or designee who received the consent letters and surveys then disseminated them to the appropriate personnel within each school. The participants were given one week to complete the survey and place it in a collection envelope to be mailed back to the student researcher or picked up by the student researcher.

Instrumentation

A survey was created after an extensive literature review and an analysis of the current *West Virginia Next Generation Content Standards and Objectives* language concerning inquiry-based instruction. The survey was reviewed during development by professors whose expertise lies in educational research. Literature supports survey review by educational professionals to ensure reliability and validity of the survey format, non-leading question development, and general readability of the survey as a whole (Bell & Waters, 2014). The survey consisted of 35 items. Eight items collected demographic data. Three items collected qualitative data from open-ended questions for participants to provide additional comments concerning inquiry-based instruction, supports, and barriers. One item used a yes/no answer format for participants to indicate use or non-use of specific inquiry-based instructional strategies. The remaining twenty-three survey items used a Likert scale ranging from 1 to 6 to determine the level of agreement or disagreement that teachers had concerning each statement. A rating of 1 indicated that teachers strongly disagreed while a rating of 6 indicated they strongly agreed with the statements.

The instrument consists of four subgroups. Questions 1-8 focus on demographic data. Question 9 focuses on teacher use of specific inquiry-based instruction methods. Questions 10-18 concentrate on teacher perceptions of their efficacy level in using inquiry-based instruction. Questions 19-32 concern teacher support or obstacles in teacher use of inquiry-based instruction. Question 33 allows participants to list their most important form(s) of support. Question 34 allows participants to list their most difficult barrier(s). Lastly, Question 35 is an open-ended question for participants to add any other comments concerning inquiry-based instruction.

A pilot study was conducted with a group of 14 current middle school science teachers in five schools located in a West Virginia county school system. The pilot study was completed to identify any survey issues concerning validity such as unclear directions, questions, answers and to address appropriateness of the language used on terms of readability. Literature supports the use of pilot studies in survey research for multiple reasons. Pilot studies allow the student researcher to “identify whether respondents understand the questions and instructions,” understand “whether the meaning of questions is the same for all respondents,” and allow the student researcher to determine if “sufficient response categories are available” to the survey participants (Kelley, Clark, Brown & Sitzia, 2003, p. 263). Twelve of 14 pilot surveys were returned. The returned surveys had minimal comments with no major suggestions for altering the survey format, language, or content.

Data Collection Procedures

Approval for the study, and its related survey, was gained through the Marshall University Institutional Review Board (Appendix A). Upon receiving approval from each counties’ superintendent or county designee, the researcher delivered the cover letter, paper survey, and collection envelope to the designated school contact or administrator. The cover letter explained that the survey was voluntary and anonymous, explained the purpose of the research study, identified risks involved, provided the researcher’s contact information, and thanked the participants for their assistance and participation. The survey contained a definition of inquiry-based instruction and directions for each subsection of the survey. The school designee or administrator disseminated the cover letter and surveys to appropriate personnel and provided one collection envelope for completed surveys.

The researcher picked up completed surveys from schools in sealed envelopes or received completed surveys by the United States Postal Service in sealed envelopes.

Statistics for Analysis of the Research Questions

Upon completion of the data collection via the paper survey, the researcher used SPSS to analyze the results. Data collected from the study was analyzed to determine instrument reliability. Cronbach's alpha, a measure of internal consistency, was chosen to analyze the results. A Cronbach Alpha reliability score was determined for the three main sections of the survey: use of Inquiry-Based Instruction strategies (Cronbach Alpha = 0.720), participant perceptions of efficacy in the use of Inquiry-Based Instruction (Cronbach Alpha = 0.719), and participant perceptions of supports and barriers experienced in their experiences with Inquiry-Based Instruction (Cronbach Alpha = 0.743). Each of these reliability measures are at the acceptable level for instrument reliability.

Research Questions

Next, the quantitative portion of this research study tested the following research questions:

Question 1: What are teachers' perceptions of their efficacy level in inquiry-based instruction methods?

Research Question 1 was explored through the use of the Chi-Square test. The Chi-Square measures whether or not there is significance in frequency of participant responses. The survey will measure teacher perceptions of efficacy level using a 6-point Likert Scale ranging from strongly disagree to strongly agree.

Question 2: What are teachers' perceptions of their extent of use of inquiry-based instruction methods?

Research Question 2 was explored through the use of the Chi-Square test. The Chi-Square measures whether or not there is significance in frequency of participant responses. The survey will measure teacher perceptions of extent of use from a yes/no response format.

Question 3: What are teachers' perceptions of the supports that allow their use of inquiry-based instruction?

Research Question 3 was explored through the use of the Chi-Square test. The Chi-Square measures whether or not there is significance in frequency of participant responses. The survey will measure teacher perceptions of support using a 6-point Likert Scale ranging from strongly disagree to strongly agree.

Question 4: What are teachers' perceptions of the obstacles that impede their use of inquiry-based instruction?

Research Question 4 was explored through the use of the Chi-Square test. The Chi-Square measures whether or not there is significance in frequency of participant responses. The survey will measure teacher perceptions of obstacles using a 6-point Likert Scale ranging from strongly disagree to strongly agree.

Question 5: What are the differences in teachers' perceptions of efficacy level in inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

Research Question 5 was explored through the use of the Mann-Whitney or Kruskal-Wallis tests. The Mann Whitney U compares participant responses and explores the association between teacher demographics and extent of efficacy level of inquiry-based instruction in the classroom using a 6-point Likert Scale ranging from strongly disagree to strongly agree. The Kruskal-Wallis test compares participant responses and determines if there are statistically significant differences between two or more groups of an independent variable.

Question 6: What are the differences in teachers' perceptions of the use of inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

Research Question 6 was explored through the use of the Chi-Square test. The Chi-Square measures whether or not there is significance in frequency of participant responses. The survey will measure teacher perceptions of extent of use using frequency counts of yes/no responses.

CHAPTER 4

ANALYSIS OF FINDINGS

Introduction

The use of inquiry-based instruction in the science classroom has been studied, debated, and advocated as effective for decades. Recently, the overhaul of the national science standards resulted in the *Next Generation Science Standards*, which support and promote the use of inquiry-based instruction in the science classroom. The purpose of this study is to gain West Virginia middle school science teachers' perceptions on their use of inquiry-based instruction. A paper survey was disseminated to 68 West Virginia middle school science teachers employed by six counties. The survey attempts to gain information concerning West Virginia middle school science teachers' understanding of inquiry-based instruction, their extent of use of inquiry-based instruction, and supports and barriers in their use of inquiry-based instruction. These data may be useful to science educator preparation programs to better prepare science teachers to use inquiry-based instruction in their classrooms. In addition, school systems and state departments of education may use the findings to understand teacher strengths and weaknesses concerning the use of, and understanding of, inquiry-based instruction. This information may assist state education departments to further hone and develop science standards that support inquiry-based instruction and to develop and offer professional development for current and future science educators.

Chapter four will present and describe the data obtained from the survey results. It will focus on teachers' perceptions of their efficacy level in the use of inquiry-based instructional methods, extent of use of inquiry-based instructional methods, and supports and barriers in the use of inquiry-based instruction. In addition, teacher demographic items related to teachers' perceptions of their efficacy and extent of use of inquiry-based instruction will be compared.

Population

A paper survey was distributed to 68 West Virginia middle school science teachers in six counties. Of the 68 surveys distributed, 57 surveys were returned. Of the 57 returned surveys, all returned useable data. The return rate was 84%.

Research Questions

The study on West Virginia middle school science teachers' perceptions on the use of inquiry-based instruction focused on the following research questions:

1. What are teachers' perceptions of their efficacy level in inquiry-based instruction methods?
2. What are teachers' perceptions of their extent of use of inquiry-based instruction methods?
3. What are teachers' perceptions of the supports that allow their use of inquiry-based instruction?
4. What are teachers' perceptions of the obstacles that impede their use of inquiry-based instruction?
5. What are the differences in teachers' perceptions of efficacy level in inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

6. What are the differences in teachers' perceptions of the use of inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

The data will reveal West Virginia middle school science teachers' perceptions on their understanding of inquiry-based instruction, their extent of use, and the supports and obstacles of the use of inquiry-based instruction in their classrooms.

Data Collection

This study is a mixed methods design, obtaining perceptions of West Virginia middle school science teachers, employed by six counties, on inquiry-based instruction. Questions one through eight consisted of demographic information concerning teachers' number of preps, years of science teaching experience, certification, class size, length and number of class times, length and number of planning times, exposure to inquiry-based instruction in educator preparation courses, and professional development opportunities related to inquiry-based instruction. Question nine used a yes/no answer format for participants to indicate use or non-use of specific inquiry-based instructional strategies. Questions 10 through 32 consisted of quantitative questions to measure teachers' perceptions of their efficacy level, support, and barriers related to inquiry-based instruction on a Likert scale, ranging from strongly disagree to strongly agree. Questions 33 through 35 were qualitative, open-ended questions that allowed teachers to describe their most important form of support in using inquiry-based instruction, their most difficult barrier that impeded the use of inquiry-based instruction, and any other comments they had in regard to inquiry-based instruction.

Research Question 1: What are teachers' perceptions of their efficacy level in inquiry-based instruction methods?

To determine West Virginia middle school science teachers' perceptions of their efficacy level in inquiry-based instruction methods (Research Question 1), questions 10 through eighteen asked participants to rate their level of agreement using a Likert scale, with 1 representing strongly disagree and 6 representing strongly agree. Table 1 shows all percentages and number of teacher responses for each statement. A Chi-square test of independence was calculated, analyzing the frequency of participant choices concerning level of agreement for each statement about teacher efficacy levels. Significance was obtained for eight of the nine statements at the $p < 0.05$ probability level.

Table 1
Teachers' Perceptions of their Efficacy Level in Inquiry- Based Instruction Methods

	Frequency of responses and percentage (n = 57 participants for each question)							
Survey Question	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Chi^2 Obtained Value	Probability level attained
Q10 Comfortable using IBI	0 (0%)	2 (3.51%)	1 (1.75%)	10 (17.54%)	15 (26.32%)	29 (50.88%)	45.719	.000*
Q11 Using IBI addresses WV NGCSO	2 (3.51%)	1 (1.75%)	0 (0%)	9 (15.79%)	19 (33.33%)	26 (45.61%)	41.509	.000*
Q12 Using IBI is most effective method	0 (0%)	0 (0%)	5 (8.77%)	10 (17.54%)	22 (38.60%)	20 (35.09%)	13.807	.003*
Q13 Received adequate IBI training in science education courses	5 (8.77%)	9 (15.79%)	8 (14.04%)	14 (24.56%)	12 (21.05%)	9 (15.79%)	5.211	.391
Q14 Students learn better using IBI vs Lecture/Text	0 (0%)	0 (0%)	6 (10.53%)	11 (19.30%)	20 (35.09%)	20 (35.09%)	10.158	.017*
Q15 Students learn better using Lecture/Text vs IBI	8 (14.04%)	19 (33.33%)	17 (29.82%)	5 (8.77%)	7 (12.28%)	1 (1.75%)	26.053	.000*
Q16 Students learn better using both IBI & Lecture/Text	0 (0%)	1 (1.75%)	1 (1.75%)	5 (8.77%)	16 (28.07%)	34 (59.65%)	69.228	.000*
Q17 Comfortable creating IBI aligned with WV NGCSO	1 (1.75%)	4 (7.02%)	4 (7.02%)	16 (28.07%)	20 (35.09%)	12 (21.05%)	30.684	.000*
Q18 WV NGCSO are effective guidelines for IBI	2 (3.51%)	5 (8.77%)	6 (10.53%)	16 (28.07%)	18 (31.58%)	10 (17.54%)	21.421	.001*

*Significance attained at the $p<0.05$ level.

In regard to the Chi-square results of the Likert scale responses, significance was attained for 8 of the 9 statements concerning teacher efficacy related to inquiry-based instruction. Descriptively, five efficacy statements, that were found to be significant, were rated by the majority of the participants towards the agreement side of the Likert Scale:

- Q10 I feel comfortable using inquiry-based instruction in my middle school science classes.
- Q11 I use inquiry-based instruction to ensure I address all required WV *Next Generation Science Standards* in my science classes.
- Q12 I believe using inquiry-based instruction is the most effective way to teach my students science.
- Q14 I believe my students learn science better when I use inquiry-based instruction than when I use lecture and text-based instruction.
- Q16 I believe my students learn science better when I use both inquiry-based instruction and lecture and text-based instruction.

Descriptively, two efficacy statements, that were found to be significant, were rated by the majority of the participants towards the agreement side of the Likert Scale but also included some participants leaning towards the disagreement side:

- Q17 I feel comfortable in my ability to create inquiry-based instruction that aligns to WV *Next Generation Science Standards*.
- Q18 The WV *Next Generation Science Standards* are effective teacher guidelines for the implementation of inquiry-based instruction.

Descriptively, one efficacy statement, that was found to be significant, was rated by the majority of the participants towards the disagreement side of the Likert Scale:

- Q15 I believe my students learn science better when I use lecture and text-based instruction than when I use inquiry-based instruction.

Interestingly, while the remaining question did not show significance with the Chi-square test, the descriptive percentages of participant responses show mixed perceptions of efficacy concerning inquiry-based instruction with a wide range of agreement and disagreement responses.

- Q13 I feel I received adequate training about using inquiry–based instruction in my science education courses.

Research Question 2: What are teachers' perceptions of their extent of use of inquiry-based instruction methods?

To determine West Virginia middle school science teachers' perceptions of their extent of use of inquiry-based instruction methods (Research Question 2), question nine asked participants to answer either yes or no in response to their use of 11 forms of inquiry-based instructional strategies in their science classes. Table 2 shows the percentages and number of teacher responses for each inquiry-based instructional strategy. A Chi-square test of independence was calculated, analyzing the frequency of participant choices concerning use for each strategy. Significance was obtained for all 11 strategies at the $p < 0.05$ probability level.

Table 2
Teachers' Perceptions of their Extent of Use of Inquiry-Based Instruction Methods

Method	Frequency of responses and percentage (n = 57 participants for each method) Yes	No	Chi^2 Obtained Value	Probability level attained
Developing Models	53 (93%)	4 (7%)	42.123	.000*
Analysis/Interpretation Data	51 (89%)	6 (11%)	35.526	.000*
Math/Computational Thinking	43 (75%)	14 (25%)	14.754	.000*
Engaging in Argument From Evidence	40 (70%)	17 (30%)	9.281	.000*
Defining Problems	49 (86%)	8 (14%)	29.491	.000*
Designing a Solution	50 (88%)	7 (12%)	32.439	.000*
Active Inquiry	48 (84%)	9 (16%)	26.684	.000*
Investigations	56 (98%)	1 (2%)	53.070	.000*
Hands-on Activities	56 (98%)	1 (2%)	53.070	.000*
Lab Skills	51 (89%)	6 (11%)	35.526	.000*
Lab Safety	54 (95%)	3 (5%)	45.632	.000*

*Significance attained at the $p<0.05$ level.

An observation of the Chi-square results shows that significance was attained for all inquiry-based instructional strategies. Overall, West Virginia middle school science teachers perceive they use all of the inquiry-based instructional strategies in their classrooms.

Descriptively, the extent of use, by percentage of yes responses, of the IBI strategies rank in the following order from used most to least in the classroom as follows:

- Investigations/Hands-on Activities (98% Yes)
- Laboratory Safety (95% Yes)
- Developing Models (93% Yes)
- Analysis & Interpretation of Data/Laboratory Skills (89% Yes)

- Designing a Solution (88% Yes)
- Defining Problems (86% Yes)
- Active Inquiry (84% Yes)
- Mathematical & Computational Thinking (75% Yes)
- Engaging in Argument from Evidence (70% Yes)

Research Question 3: What are teachers' perceptions of the supports that allow their use of inquiry-based instruction?

Research Question 4: **What are teachers' perceptions of the obstacles that impede their use of inquiry-based instruction?**

In order to determine teachers' perceptions of the supports that allow their use of inquiry-based instruction and the obstacles that impede their use of inquiry-based instruction (Research Questions 3 & 4), statements 19-32 asked participants to rate their level of agreement using a Likert scale, with 1 representing strongly disagree and 6 representing strongly agree. Table 3 shows the complete number of responses and percentages from teacher participants. A Chi-square test of independence was calculated, analyzing the frequency of participant choices concerning level of agreement for each statement concerning supports and obstacles of inquiry-based instruction. Significance was attained for 9 of the 14 statements at the $p<0.05$ probability level.

Table 3
Teachers' Perceptions of Supports & Obstacles in the Use of Inquiry-Based Instruction

	Frequency of responses and percentage (n = 57 participants for each question)							
Survey Question	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Chi^2 Obtained Value	Probability level attained
Q19 Enough lab supplies to use IBI	16 (28.07%)	11 (19.30%)	9 (15.79%)	13 (22.81%)	6 (10.53%)	2 (3.51%)	13.211	.021*
Q20 Enough lab space to use IBI	12 (21.05%)	8 (14.04%)	9 (15.79%)	9 (15.79%)	8 (14.04%)	11 (19.30%)	1.421	.922
Q21 Enough technology to use IBI	9 (15.79%)	8 (14.04%)	4 (7.02%)	14 (24.56%)	13 (22.81%)	9 (15.79%)	6.895	.229
Q22 Enough planning time to use IBI	8 (14.04%)	8 (14.04%)	8 (14.04%)	11 (19.30%)	14 (24.56%)	8 (14.04%)	3.316	.651
Q23 Enough class time to use IBI	9 (15.79%)	4 (7.02%)	7 (12.28%)	13 (22.81%)	16 (28.07%)	8 (14.04%)	9.842	.080
Q24 Student's enjoyment & engagement in IBI	0 (0%)	0 (0%)	1 (1.75%)	12 (21.05%)	24 (42.11%)	20 (35.09%)	21.667	.000*
Q25 IBI Prepares students for Standardized Testing	4 (7.02%)	7 (12.28%)	0 (0%)	17 (29.82%)	17 (29.82%)	12 (21.05%)	12.035	.017*
Q26 Class Size supports IBI	1 (1.75%)	8 (14.04%)	13 (22.81%)	11 (19.30%)	13 (22.81%)	11 (19.30%)	10.895	.054
Q27 Admins support IBI	0 (0%)	0 (0%)	1 (1.75%)	4 (7.02%)	16 (28.07%)	36 (63.16%)	53.105	.000*
Q28 Parents/Community support the use of IBI	12 (21.05%)	7 (12.28%)	4 (7.02%)	16 (28.07%)	13 (22.81%)	5 (8.77%)	12.368	.030*
Q29 Central Office supports IBI	2 (3.51%)	6 (10.53%)	0 (0%)	12 (21.05%)	16 (28.07%)	21 (36.84%)	20.281	.000*
Q30 WVDE supports use of IBI	2 (3.51%)	1 (1.75%)	7 (12.28%)	10 (17.54%)	14 (24.56%)	23 (40.35%)	35.526	.000*
Q31 Students off-task with use of IBI	14 (24.56%)	8 (14.04%)	4 (7.02%)	24 (42.11%)	6 (10.53%)	1 (1.75%)	36.579	.000*
Q32 Difficulty with student management	13 (22.81%)	10 (17.54%)	11 (19.30%)	15 (26.32%)	7 (12.28%)	1 (1.75%)	13.000	.023*

*Significance attained at the p<0.05 level.

In regard to the Chi-square results of the Likert scale responses, significance was attained for 9 of the 14 statements concerning teacher perceptions of supports and barriers related to inquiry-based instruction. Descriptively, five forms of support, that were found to be significant, were rated by the majority of the participants towards the agreement side of the Likert Scale:

- Q24 Inquiry-based instruction is supported by my students' level of enjoyment and engagement in science class.
- Q25 Implementing inquiry-based instruction prepares my students for state standardized assessments.
- Q27 My principal/school administration supports the use of inquiry-based instruction.
- Q29 My county central office supports the use of inquiry-based instruction.
- Q 30 The WV Department of Education supports the use of inquiry-based instruction.

Also, in terms of supports in the use of inquiry-based instruction, two statements, where significance was attained, were rated by many of the participants towards the disagreement side of the Likert Scale along with several responses of only slightly agree:

- Q31 Students are often off-task during inquiry-based instruction.
- Q32 Students are difficult to manage when I use inquiry-based instruction activities.

In terms of obstacles in the use of inquiry-based instruction, two statements, where significance was attained, were rated by many of the participants towards the disagreement side of the Likert Scale along with several responses of only slightly agree or moderately agree:

- Q19 I have enough laboratory supplies to support the implementation of inquiry-based instruction in my science classes.
- Q28 I have parent and/or community participation that supports the implementation of inquiry-based instruction.

Interestingly, while the remaining five questions did not show significance with the Chi-square test, the descriptive percentages of participant responses show mixed perceptions of obstacles and supports concerning inquiry-base instruction, with a wide range of agreement and disagreement responses:

- Q20 I have enough laboratory space to safely and effectively support the use of inquiry-based instruction in my science classes.
- Q21 I have enough relevant technology to effectively implement inquiry-based instruction in my science classes.
- Q22 I have enough planning time to support the implementation of inquiry-based instruction in my science classes.
- Q23 I have enough teaching time to support the implementation of inquiry-based instruction in my science classes.
- Q26 My class size is appropriate for the use of inquiry-based instruction.

Research Question 3 Qualitative Data for Supports

Question 33 asked respondents to list their most important forms of support for using inquiry-based instruction. Eleven of the 57 respondents left question 33 blank. A counting method was used to determine the categories that emerged from the support theme. Ten categories representing forms of support emerged from the qualitative data and are ranked in order from most to least frequently listed for question 33:

- Administration (Principals/County Level) 20 Occurrences
- Colleagues/Collaboration 11 Occurrences
- Technology 6 Occurrences
- Laboratory Supplies 5 Occurrences

- Professional Development 5 Occurrences
- Funding 4 Occurrences
- Student Enjoyment/Engagement 4 Occurrences
- Time (Planning/Class) 4 Occurrences
- WV Next Gen CSOs 4 Occurrences
- Laboratory Space 1 Occurrence

Research Question 4 Qualitative Data for Obstacles

Question 34 asked respondents to list their most difficult obstacle when using inquiry-based instruction. Six of the 57 respondents left question 34 blank. The researcher used a counting method to determine the categories that emerged from the obstacle theme. Nine categories of obstacles emerged from the qualitative data and are ranked in order from most to least frequently listed for question 34:

- Lack of Laboratory Supplies 19 Occurrences
- Student Behavior/Ability Levels 18 Occurrences
- Lack of Funding 17 Occurrences
- Not Enough Time (Planning/Class) 16 Occurrences
- Lack of Laboratory Space 10 Occurrences
- Large Class Sizes 8 Occurrences
- Lack of Professional Development 4 Occurrences
- WV Next Gen CSOs 4 Occurrences
- Lack of Experience Using IBI 3 Occurrences

Research Question 5: **What are the differences in teachers' perceptions of efficacy level in inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?**

Certification Endorsement

To measure significance of efficacy levels with certification endorsement (Research Question 5), the Mann-Whitney U test was performed to compare the two mean ranks of independent groups of Middle School Endorsement and No Middle School Endorsement responses. Table 4 presents the 10 statements concerning teacher efficacy level and the Mann-Whitney U results. Table 4 presents statement results found to be significant ($p<0.05$).

Table 4
Certification Endorsement

(n = 57 participants for each question)				
Certification	Middle School Endorsement Mean Rank (n = 40)	No Middle School Endorsement Mean Rank (n = 17)	Mann-Whitney U Obtained Value	Probability level attained
Q10 Comfortable using IBI	32.25	21.35	210.0	.014*
Q11 Using IBI addresses WV NGCSO	32.11	21.68	215.5	.019*
Q13 Received adequate IBI training in science education courses	32.04	21.85	218.5	.031*
Q17 Comfortable creating IBI aligned with WV NGCSO	32.29	21.26	208.5	.017*

*Significance attained at the $p<0.05$ level.

Certification made a significant difference in Likert scale choices for the following statements:

- Q10 I feel comfortable using inquiry-based instruction in my middle school science classes.

- Q11 I use inquiry-based instruction to ensure I address all required WV *Next Generation Science Standards* in my science class.
- Q13 I feel I received adequate training about using inquiry-based instruction in my science education courses.
- Q17 I feel comfortable in my ability to create inquiry-based instruction that aligns to WV *Next Generation Science Standards*.

The scores of the Likert scale ranged from 1 representing strongly disagree to 6 representing strongly agree. Due to this rating scale, the comparisons of mean ranks with significance ($p<0.05$), illustrates that West Virginia middle school science teachers with No Middle School Science Endorsement chose lower ranks than Middle School Science Endorsed teachers, perhaps indicating they perceived their efficacy level of inquiry-based instruction to be lower.

Class Time

To measure significance of efficacy levels with class time (Research Question 5), the Mann-Whitney U test was performed to compare the two mean ranks of independent samples of Class Time of 59 minutes or Less and Class Time of 60 minutes or More responses. Table E5 (Appendix E) presents the 10 statements concerning teacher efficacy level and the Mann-Whitney U results. Table 5 presents all statement results of significance ($p<0.05$).

Table 5
Class Time

Class Time	59 Minutes or Less Mean Rank (n = 47)	60 Minutes or More Mean Rank (n = 10)	Mann-Whitney U Obtained Value	Probability level attained
	(n = 57 participants for each question)			
Q10 Comfortable using IBI	30.95	19.85	143.5	.037*
Q11 Using IBI addresses WV NGCSO	31.34	18.00	125.0	.013*
Q13 Received adequate IBI training in science education courses	31.40	17.70	122.0	.016*
Q17 Comfortable creating IBI aligned with WV NGCSO	32.14	14.25	87.5	.001*
Q18 WV NGCSO effective guidelines for IBI	32.18	14.05	85.5	.001*

*Significance attained at the p<0.05 level.

Class Time made a significant difference in Likert scale choices for the following statements:

- Q10 I feel comfortable using inquiry-based instruction in my middle school science classes.
- Q11 I use inquiry-based instruction to ensure I address all required WV *Next Generation Science Standards* in my science class.
- Q13 I feel I received adequate training about using inquiry-based instruction in my science education courses.
- Q18 The *WV Next Generation Science Standards* are effective teacher guidelines for the implementation of inquiry-based instruction.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. From this rating scale, the comparisons of mean ranks with significance, shows that West Virginia middle school science teachers with Class Time of 60 minutes or More chose lower ranks in all five statements concerning efficacy level in inquiry-based instruction.

Planning Time

To measure significance of efficacy levels with planning time (Research Question 5), the Mann-Whitney U test was performed to compare the two mean ranks of independent samples of Planning Time of 59 minutes or Less and Planning Time of 60 minutes or More responses. Table E6 (Appendix E) presents all statements concerning teacher efficacy level and the Mann-Whitney U results. Table 6 presents all statement results of significance ($p<0.05$).

Table 6
Planning Time

	(n = 57 participants for each question)			
Planning Time	59 Minutes or Less Mean Rank (n = 38)	60 Minutes or More Mean Rank (n = 29)	Mann-Whitney U Obtained Value	Probability level attained
Q11 Using IBI addresses WV NGCSO	34.73	23.47	245.5	.006*
Q13 Received adequate IBI training in science education courses	35.09	23.12	235.5	.006*

*Significance attained at the $p<0.05$ level.

Planning Time made a significant difference in Likert scale choices for the following statements:

- Q11 I use inquiry-based instruction to ensure I address all required WV *Next Generation Science Standards* in my science classes.
- Q13 I feel I received adequate training about using inquiry-based instruction in my science education courses.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. From this rating scale, the comparisons of mean ranks with significance ($p<0.05$), shows that West Virginia middle school science teachers with Planning Time of 60 minutes or More chose lower ranks in both statements concerning efficacy level in inquiry-based instruction.

Number of Preps

To measure significance of efficacy levels with number of preparations (Research Question 5), the Kruskal-Wallis test was performed to compare the three mean ranks of independent samples of 1 Prep, 2 Preps, or 3 Preps responses. The three choices of number of preps correlate to middle school science grade levels of sixth, seventh, and eighth. For example, if a respondent chose only sixth grade as their response, they would be considered as teaching 1 Prep. Table E7 (Appendix E) presents the 10 statements concerning teacher efficacy level and the Kruskal-Wallis results. Table 7 below statement results of significance ($p<0.05$).

Table 7
Number of Preps

		(n=57 participants for each question)			
Number of Preps	1 Prep Mean Rank (n = 39)	2 Preps Mean Rank (n = 13)	3 Preps Mean Rank (n = 5)	Kruskal-Wallis Obtained Value	Probability level attained
Q10 Comfortable using IBI	25.44	36.00	38.60	6.845	.033*
Q11 Using IBI addresses WV NGCSO	24.51	38.23	40.00	10.490	.005*

*Significance attained at the $p<0.05$ level.

Number of Preps made a significant difference in Likert scale choices for the following statements:

- Q10 I feel comfortable using inquiry-based instruction in my middle school science classes.
- Q11 I use inquiry-based instruction to ensure I address all required WV *Next Generation Science Standards* in my science class.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. From this rating scale, the comparisons of mean ranks with significance, shows that West Virginia middle school science teachers with 1 Prep chose lower ranks than respondents teaching 2 or 3 Preps in both statements concerning efficacy level in inquiry-based instruction. These results were completed using a pair-wise comparison of test results.

Professional Development

To measure significance of efficacy levels with number of inquiry-based instruction professional development opportunities attended (Research Question 5), the Kruskal-Wallis test was performed to compare the three mean ranks of independent samples of Attended 1, Attended 2 or more, or Attended None responses. Table E8 (Appendix E) presents the 10 statements concerning teacher efficacy level and the Kruskal-Wallis results. Table 8 presents statement results of significance.

Table 8
Professional Development Attendance

(n = 57 participants for each question)					
Professional Development	Attended 1 Mean Rank (n = 14)	Attended 2 or More Mean Rank (n = 32)	Attended None Mean Rank (n = 11)	Kruskal-Wallis Obtained Value	Probability level attained
Q10 Comfortable using IBI	26.86	33.48	18.68	8.072	.018*
Q12 Using IBI is most effective method	20.61	34.53	23.59	9.291	.010*
Q13 Received adequate IBI training in science education courses	27.29	35.14	13.32	14.871	.001*

*Significance attained at the $p<0.05$ level.

Number of Professional Development opportunities attended made a significant difference in Likert scale choices for the following statements:

- Q10 I feel comfortable using inquiry-based instruction in my middle school science classes.
- Q12 I believe using inquiry-based instruction is the most effective way to teach my students science.
- Q13 I feel I received adequate training about using inquiry-based instruction in my science education courses.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. From this rating scale, the comparisons of mean ranks with significance, shows that West Virginia middle school science teachers that Attended None chose lower ranks than respondents who had Attended 1 or Attended 2 or more professional development opportunities on inquiry-based instruction for statement 10 concerning teacher comfort levels in using IBI. These results were determined by conducting a pair-wise comparison of test results.

Concerning statement 12, that focused upon the perception that teachers believe using IBI is the most effective method to teach students science, respondents who had Attended 2 or more inquiry-based instruction professional development opportunities chose higher ranks than respondents who Attended 1 or Attended None. Again, a pair-wise comparison was conducted on the test results.

Statement 13 asked respondents to rate whether they had received adequate training on inquiry-based instruction during their science education courses. Respondents that had Attended None chose lower ranks than those that had Attended 1 or Attended 2 or more IBI professional development opportunities. A pair-wise comparison was conducted on the test results.

Years of Science Teaching Experience

To measure significance of efficacy levels with number of years of science teaching experience (Research Question 5), the Kruskal-Wallis test was performed to compare the four mean ranks of independent samples of 5 Years or Less, 6-10 Years, 11-15 Years, and Greater than 15 Years responses. Table E9 (Appendix E) presents the 10 statements concerning teacher efficacy level and the Kruskal-Wallis results. Table 9 presents statement results of significance ($p<0.05$).

Table 9
Years of Science Teaching Experience

	(n=57 participants for each question)					
Years of Science Teaching	5 Years or Less Mean Rank (n = 20)	6-10 Years Mean Rank (n = 12)	11-15 Years Mean Rank (n = 14)	Greater Than 15 Years Mean Rank (n = 11)	Kruskal-Wallis Obtained Value	Probability Level attained
Q13 Received adequate IBI training in science education courses	20.27	32.12	36.96	31.32	9.732	.021*

*Significance attained at $p<0.05$ level.

Years of Science Teaching Experience made a significant difference in Likert scale choices for the following statement:

- Q13 I feel I received adequate training about using inquiry-based instruction in my science education courses.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. From this rating scale, the comparisons of mean ranks with significance, shows that West Virginia middle school science teachers with 5 Years or Less science teaching experience chose lower ranks than respondents with 6-10 Years, 11-15 Years, and Greater than 15 Years' experience in the statement concerned with receiving adequate inquiry-based instruction training in science education courses. A pair-wise comparison was conducted on the test results.

Course Work

To measure significance of efficacy levels with exposure to inquiry-based instruction in science education course work (Research Question 5), the Kruskal-Wallis test was performed to compare the three mean ranks of independent samples of Exposed Once, Exposed Twice, Never Exposed responses. The participants were given the options to choose from inquiry-based instruction exposure during their bachelor's degree, master's degree, or never exposed during my course work. Table E10 (Appendix E) presents all statements concerning teacher efficacy level and the Kruskal-Wallis results. Table 10 presents statement results of significance ($p<0.05$).

Table 10
Exposure to Inquiry Based Instruction during Science Education Course Work

	(n=57 participants for each question)				
Course Work	Once Mean Rank (n = 31)	Twice Mean Rank (n = 10)	Never Mean Rank (n = 16)	Kruskal-Wallis Obtained Value	Probability level attained
Q13 Received adequate IBI training in science education courses	32.00	41.45	14.30	19.109	.000*

*Significance attained at the $p<0.05$ level.

Exposure to inquiry-based instruction during Science Education Course Work made a significant difference in Likert scale choices for the following statement:

- Q13 I feel I received adequate training about using inquiry-based instruction in my science education courses.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. From this rating scale, the comparisons of mean ranks with significance, shows that West Virginia middle school science teachers that selected Never Exposed to inquiry-based instruction in science education course work chose lower ranks than respondents that were exposed Once or Twice in the statement concerned with receiving adequate inquiry-based instruction training in science education course work. A pair-wise comparison was used to determine results.

Class Size

To measure significance of efficacy levels with class size (Research Question 5), the Mann-Whitney U test was performed to compare the two mean ranks of independent samples of 24 Students or Less and More than 24 Students responses. Table E11 (Appendix E) presents the 10 statements concerning teacher efficacy level and the Mann-Whitney U results. Table 11 presents statement results of significance.

Table 11
Class Size

(n=57 participants for each question)				
Class Size	24 students or less Mean Rank (n = 22)	More than 24 students Mean Rank (n = 35)	Mann-Whitney U Obtained Value	Probability level attained
Q14 Students learn better using IBI vs Lecture/Text	23.64	32.37	503.0	.042*

* Significance attained at $p<0.05$ level.

Class Size made a significant difference in Likert scale choices for the following statement:

- Q14 I believe my students learn science better when I use inquiry-based instruction than when I use lecture and text-based instruction.

The scores of the Likert scale ranged from 1 for strongly disagree to 6 for strongly agree. Due to this rating scale, the comparisons of mean ranks with significance, illustrates that West Virginia middle school science teachers with Class Size of More than 24 Students chose higher ranks than Class Size of 24 or Less Students for statement 14.

Research Question 6: What are the differences in teachers' perceptions of the use of inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

With the exception of two Chi-square analyses, the Chi-square tests resulted in no significant differences in use of each of the inquiry-based instructional strategies due to participant demographic groupings (Tables E12-E19 in Appendix E). The two analyses that did show significance were the certification demographic and the laboratory safety inquiry-based instructional strategy (Table 12), and the class time demographic and the engaging in argument from evidence inquiry-based instructional strategy (Table 13). Because the data for these two analyses both resulted in some of the expected frequency cells containing less than 5 frequencies, the more conservative Fischer's Exact Test was used to note the probability level attained. Therefore, it is concluded that overall participant demographics do not show significant differences between demographic groups related to participant use of inquiry-based instructional strategies, except for the two incidences of certification and class time. These exceptions will be further explored in Chapter 5.

Table 12

Certification and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Laboratory Safety					
Middle School Endorsement	40	0	7.451	.006	.023 *
No Middle School Endorsement	14	3			

* Significance attained at p<0.05.
** Fisher's Exact Test probability used due to expected cells that contained expected count less than 5.

Table 13
Class Time and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Engaging in Argument from Evidence					
59 minutes or less	37	10	9.353	.002	.005 *
60 minutes or more	3	7			

* Significance attained at p<0.05.
** Fisher's Exact Test probability used due to expected cells that contained expected count less than 5.

Summary of Findings

This chapter described the findings and data analysis of the study to determine West Virginia middle school science teachers' perceptions on the use of inquiry-based instruction. West Virginia middle school science teacher respondents were asked to complete a paper survey that consisted of demographics, extent of use of inquiry-based instructional strategies, efficacy levels of inquiry-based instruction, and supports and barriers in the use of inquiry-based instruction. The data was analyzed using Chi-square, Mann-Whitney U, Kruskal-Wallis, 2x2 Chi-square, Fishers Exact Test, and Descriptive Statistics.

Concerning middle school science teacher efficacy levels in inquiry-based instruction, most believe they understand inquiry-based instruction and believe it is beneficial to teach students science using these methods. The areas concerning teacher comfort levels in creating inquiry-based instruction that aligns to WV *Next Generation Science Content Standards and Objectives* and that the standards are effective teacher guidelines did not reveal levels of strong agreement and may indicate less efficacy levels for some groups. Additionally, there were inconsistent responses for the statement concerning received adequate training on inquiry-based instruction through science education courses. This inconsistent response may indicate that some science educator preparation programs are doing a good job instructing pre-service teachers in the area of inquiry-based instruction in the science classroom while other programs may not.

West Virginia middle school science teachers' extent of use of inquiry-based instructional strategies revealed that the majority of respondents all perceived they used all strategies listed on the survey. The level of use was less evident in the areas of mathematical and computational thinking and engaging in argument from evidence.

Concerning supports of inquiry-based instruction, West Virginia middle school science teachers believed administration, central office staff, state department of education, and student level of enjoyment were supportive of inquiry-based instruction. Descriptive data further indicated that administration and colleague collaboration were major factors of support in the use of inquiry-based instruction.

West Virginia middle school science teachers' perceptions on obstacles in the use of inquiry-based instruction cited lack of laboratory supplies and materials and lack of parent and community participation as prohibitive. Descriptive data further conveyed that a lack of supplies, student behavior and ability levels, lack of funding, and lack of class and planning time as major obstacles in the use of inquiry-based instruction. In addition, many inconsistent responses arose in areas of laboratory space, relevant technology availability, planning time, class time, and class size indicating that dependent upon respondents' county of employment some of these may be obstacles or supports for inquiry-based instruction.

Teacher demographics in relation to efficacy levels in inquiry-based instruction indicated that West Virginia middle school science teachers without middle school science endorsement felt less comfortable using and creating inquiry-based instruction and felt they did not receive adequate training according to a mean ranks comparison. In terms of class time, middle school science teachers with class times of 60 minutes or more felt less comfortable using inquiry-based instruction, less likely to use inquiry-based instruction to meet state standards, less adequately trained on inquiry-based instruction, and that the state standards were not adequately met using inquiry-based instruction. Planning times of 60 minutes or more also revealed respondents felt less likely to use inquiry-based instruction to meet state standards and felt less adequately trained on the use of inquiry-based instruction.

In relation to efficacy levels and inquiry-based instruction professional development opportunities, respondents who had attended none chose lower ranks in comfort of use and felt less adequately trained. Respondents who had attended two or more professional development opportunities chose higher ranks in the effectiveness of using inquiry-based instruction to teach science to students. Respondents who had five years or less science teaching experience and respondents who were never exposed to inquiry-based instruction in their science education course work felt they were less adequately trained. Lastly, respondents with a class size of more than 24 students felt students learn science better using inquiry-based instruction. In relation to teacher demographics and extent of use of inquiry-based instruction, minimal significance was found.

CHAPTER 5

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

This chapter includes the purpose, study population, and methodology used in this study. A summary of data findings organized around the six research questions is followed by a discussion of conclusions and implications. Recommendations for further research conclude the chapter, as well as closing remarks.

Purpose of the Study

The purpose of the study was to gain the perceptions of West Virginia middle school science teachers on inquiry-based instruction. The areas of efficacy level, extent of use, and supports and barriers were measured for inquiry-based instruction. Demographic variables and their relationship to inquiry-based instruction were also compared. Demographic variables included number of preps, area of certification, years of experience, class time, planning time, exposure to inquiry-based instruction in science education course work, attendance of professional development opportunities related to inquiry-based instruction, and class size. In addition, teachers were asked to list any other comments they had concerning inquiry-based instruction and their most important form of support and largest barrier. The overarching goal was to determine the perception that middle school science teachers had concerning the use of inquiry-based instruction, as it is the recommended form of science instruction for student engagement and achievement. The following six research questions guided the study:

1. What are teachers' perceptions of their efficacy level in inquiry-based instruction methods?
2. What are teachers' perceptions of their extent of use of inquiry-based instruction methods?

3. What are teachers’ perceptions of the supports that allow their use of inquiry-based instruction?
4. What are teachers’ perceptions of the obstacles that impede their use of inquiry-based instruction?
5. What are the differences in teacher’s perceptions of efficacy level in inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?
6. What are the differences in teachers’ perceptions of the use of inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

Demographic Data

The population for this study included 68 middle school science teachers employed by 26 schools located in six West Virginia counties. The participants completed a four-part paper survey that included eight demographic questions, one extent of use question, nine efficacy level questions, 14 support and barrier questions, and three open-ended response questions concerning supports, barriers, and any other comments, respectively.

Methods

The study was completed using both quantitative and qualitative methods. The four-part paper survey was disseminated to 68 West Virginia middle school science teachers. The survey included 35 items concerning demographic data, extent of use, efficacy level, supports and barriers, and further comments. The extent of use question used a yes/no format to determine which inquiry-based instructional strategies were being used. The efficacy level and supports and barriers questions used a Likert scale rating with 1 representing strongly disagree and 6 representing strongly agree concerning teachers' perceptions. The survey was piloted to 14 West Virginia middle school science teachers employed by a county outside of the research study. The pilot surveys were returned with minimal comments and confirmed validity of the survey.

The surveys were either hand-delivered by the student researcher to school administrators or delivered via United States Postal Service to a school or county level contact person. The student researcher retrieved some surveys in sealed envelopes from schools directly or they were mailed to the student researcher's home address in self-addressed stamped envelopes. 57 out of 68 respondents returned their surveys with all six counties having representation. All 57 respondents completed the survey with useable data.

Research question one was analyzed using a Chi-square test to determine significance and frequency of responses and percentages concerning efficacy level were calculated for respondents. Research question two was analyzed using a Chi-square test to determine significance and frequency and percentages of yes/no responses were calculated concerning use of inquiry-based instructional methods. Research questions three and four were also analyzed using a Chi-square test to determine significance and frequency and percentages concerning supports and barriers to inquiry-based instruction were calculated. In addition, qualitative counting and ranking were completed on open-ended responses concerning supports and barriers. The Mann-Whitney U test and Kruskal-Wallis test were used to analyze research question five to determine significance between demographic items and teachers' perceived efficacy levels. The mean ranks were obtained for categories of the demographic data. For research question six, a 2x2 Chi-square was used to analyze and determine significance between teachers' perceptions of extent of use and demographic variables. Due to low number of frequencies in the frequency cells, a Fishers Exact test was used to clarify and confirm probability results.

Summary of Data Findings

Findings from the data are summarized for each research question:

Question 1: What are teachers' perceptions of their efficacy level in inquiry-based instruction methods?

Overall, West Virginia middle school science teachers perceived they understand inquiry-based instruction and are comfortable using inquiry-based instruction in the classroom. The majority of the respondents agreed (96.49%) with statement 16, *I believe my students learn science better when I use both inquiry-based instruction and lecture and text-based instruction,* 89.48% agreed with statement 14 *I believe my students learn science better when I use inquiry-based instruction than when I use lecture and text-based instruction* and statement 12 *I believe using inquiry-based instruction is the most effective way to teach my students science* (91.23%). In addition, 94.74% of respondents agreed with statement 10 *I feel comfortable using inquiry-based instruction in my middle school science classes* and statement 11 *I use inquiry-based instruction to ensure I address all required WV Next Generation Science Standards in my science classes* (87.72%). The majority of respondents disagreed with statement15 *I believe my students learn science better when I use lecture and text-based instruction than when I use inquiry-based instruction* (77.19%).

Conversely, only 15.79% of respondents strongly agreed with statement 13 *I feel I received adequate training about using inquiry-based instruction in my science education courses*. In addition, statement 17 *I feel comfortable in my ability to create inquiry-based instruction that aligns to WV Next Generation Science Standards* and statement 18 *The WV Next*

Generation Science Standards are effective teacher guidelines for the implementation of inquiry-based instruction received agreement by the majority of respondents, but also included some respondents leaning toward the disagreement side. While statement 13 *I feel I received adequate training about inquiry-based instruction in my science education courses* did not show significance, the descriptive percentages indicate that there is little consistency concerning this topic among respondents.

Question 2: What are teachers' perceptions of their extent of use of inquiry-based instruction methods?

The Chi-square results indicate that West Virginia middle school science teachers believe they are using all inquiry-based strategies in the classroom. Investigations, hands-on activities, laboratory safety, and developing models all achieved over 90% yes responses. Mathematical and computational thinking and engaging in argument from evidence were the least used inquiry-based instructional strategies at 75% and 70% yes responses, respectively.

Question 3: What are teachers' perceptions of the supports that allow their use of inquiry-based instruction methods?

West Virginia middle school science teachers from this study believe their administration strongly supports the use of inquiry-based instruction (Q27 98.25%) as does the West Virginia Department of Education (Q30 82.45%) and the county central offices (Q29 85.96%). In addition, statement 24 *Inquiry-based instruction is supported by my students' level of enjoyment and engagement in science class* received majority agreement (98.25%). Also, statement 25 *Implementing inquiry-based instruction prepares my students for state standardized assessments* had majority agreement at 80.69%.

Two statements, 31 *Students are often off-task during inquiry-based instruction* and 32 *Students are difficult to manage when I use inquiry-based instruction activities* attained significance and were rated by many respondents in the area of disagreement (Q31 45.62% & Q32 59.65%). The significance attained indicates that many of the respondents view student behavior as a support.

Qualitative data reinforced the belief that principal support is the number one factor influencing and motivating West Virginia middle school science teachers in their use of inquiry-based instruction. The qualitative data also revealed that respondents felt colleague collaboration was the second most important form of support in using inquiry-based instruction. Interestingly, qualitative data conflicted with the Likert scale findings on student behavior, where most participants disagreed that student behavior was an obstacle. For question 34 regarding the most significant obstacle, many respondents mentioned that student behavior and student's being off-task as barriers to the use of inquiry-based instruction.

Question 4: What are teachers' perceptions of the obstacles that impede their use of inquiry-based instruction methods?

The significant results that describe barriers West Virginia middle school science teachers face are a lack of laboratory supplies, lack of parent and community participation, and student behavior issues. Statement 19 *I have enough laboratory supplies to support the implementation of inquiry-based instruction in my science classes* received 63.16% disagreement from respondents, but interestingly 36.85% of respondents agreed indicating inconsistencies throughout the respondents' counties perhaps. Statement 28 *I have parent and/or community participation that supports the implementation of inquiry-based instruction* received 40.35%

disagreement from respondents, but again inconsistency was revealed with 59.65% of respondents that agreed.

While five questions did not show significance, the descriptive percentages revealed that the majority of respondents had inconsistent perceptions about the following obstacles and supports for inquiry-based instruction: laboratory space, technology, planning time, teaching time, and class size. These results indicate and reveal that there is little consistency across county borders concerning funding, facilities, population of students, technology availability, and structure of the day concerning time.

The qualitative data confirmed that lack of laboratory supplies and student behavior were two of the most prohibitive factors that impede the use of inquiry-based instruction. The qualitative data also revealed that West Virginia middle school science teachers in this study felt student ability levels, lack of funding, and a lack of class and planning time deterred their use of inquiry-based instruction. The qualitative data conflict with some of the Likert scale responses, particularly with the student behavior issues.

Question 5: What are differences in teachers' perceptions of efficacy level in inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

Overall, West Virginia middle school science teachers significantly chose lower mean ranks for efficacy level in the following demographic categories:

1. No middle school science endorsement
2. Class Time of greater than 60 minutes
3. Plan Time of greater than 60 minutes

4. Grade Levels: 1 Prep
5. Have not attended Professional Development
6. 5 years or less science teaching experience
7. Not covered in my course work

Statement 10, *I feel comfortable using inquiry-based instruction in my middle school science classes,* was significant, meaning the respondents chose lower ranks for efficacy level in the following demographic categories: no middle school science endorsement, class times of 60 minutes or more, had 1 Prep, and never attended a professional development opportunity. Statement 11, *I use inquiry-based instruction to ensure I address all required WV Next Generation Science Standards in my science classes,* was significant for respondents, meaning they chose lower efficacy level ranks, in the categories of no middle school science endorsement, class times and planning times of 60 minutes or more, and taught 1 Prep.

Statement 13, *I feel I received adequate training about using inquiry–based instruction in my science education courses,* resulted in significantly lower mean ranks for six demographic categories, the most of any efficacy level statement. The respondents in the categories of no middle school endorsement, class and planning times of 60 minutes or more, attended no professional development opportunity, less than five years of science teaching experience, and never exposed to inquiry-based instruction in science education course work all chose lower mean ranks for this statement on efficacy.

Lastly, respondents with class times of 60 minutes or more significantly chose lower mean ranks for statements 17 and 18*, I feel comfortable in my ability to create inquiry-based instruction that aligns to WV Next Generation Science Standards* and *The WV Next Generation Science Standards are effective teacher guidelines for the implementation of inquiry-based* *instruction*, respectively. The deduced reasons these lower mean ranks are occurring within demographic categories will be discussed in more detail.

West Virginia middle school science teachers that had attended two or more professional development opportunities significantly chose higher mean ranks for efficacy level for statement 12, *I believe using inquiry-based instruction is the most effective way to teach my students science*. In addition, respondents that had greater than 24 or more students significantly chose higher mean ranks for statement 14, *I believe my students learn science better when I use inquiry-based instruction than when I use lecture and text-based instruction*.

Question 6: What are differences in teachers' perceptions of the use of inquiry-based instruction due to demographic factors such as: number of preps, area of certification, years of experience, class time, planning time, inquiry-based instruction training, and class size?

Only two demographic categories resulted in significance in terms of mean ranks for the extent of use of inquiry-based instruction. West Virginia middle school science teachers with no middle school endorsement significantly chose more no responses for use of the laboratory safety inquiry-based instructional strategy. For the category of engaging in argument from evidence inquiry-based instructional strategy, respondents with class times of 60 minutes or more ranked higher in no responses. These 2x2 Chi-square results had to be further clarified through the use of the Fischer Exact Test due to small number of frequencies found within the frequency cells. The exceptions described above indicate that West Virginia middle school science teachers do not, as a whole, choose specific inquiry-based instructional strategies in relationship to the various demographics that were explored.

Discussion of Conclusions and Implications

The following discussion regarding conclusions and implications is organized into six categories that focus on issues related to inquiry-based instruction. The first section focuses on Efficacy Levels. Section two considers Extent of Use. The third section focuses on both Support and Barriers. Section four considers Demographic Relationships. Section five considers Additional Comments. The final section delivers a summary of the implications derived from the study.

Efficacy Levels in Inquiry-Based Instruction

In terms of efficacy, this study shows West Virginia middle school science teachers perceive they have the ability to produce the desired result of using inquiry-based instruction, rather than a lecture/text-based instruction, to effectively teach science to students. Numerous studies indicate that using inquiry-based instruction increases student achievement, student engagement, scientific literacy, process skills, and student attitudes toward science (Bredderman, 1983; Lindberg, 1990; Shymanksky et al., 1983). In fact, inquiry-based instruction is the preferred and recommended method of science instruction at the national level (National Research Council, 2013).

While this study revealed that the majority of the middle school science teacher participants felt comfortable using inquiry-based instruction, felt it was the most effective method of teaching science, and felt the use of inquiry-based instruction helped them address the *West Virginia Next Generation Content Standards and Objectives*, West Virginia middle school students are not showing improvement on standardized tests. According to the Zoom WV Data Dashboard, only 38.32% of all middle school students in West Virginia had achieved proficiency in science during the school year 2016-2017. For the combined districts in the research study, science proficiency among middle school students was even lower at 33% (West Virginia Department of Education, 2018). This disconnect between teacher perceptions of their efficacy and use of inquiry and student performance raises some serious questions.

Other details in the data analysis might give some explanation for student low science scores. This study revealed for the participants of this study, less than 16% of the respondents felt they had received adequate training on the use of inquiry-based training in their science education course work. Through further analysis of the data, it was revealed that almost 30% of the respondents were not certified to teach middle school science, 35% of the respondents had less than 5 years of experience, 44% of the respondents had never attended or attended only one inquiry-based instruction professional development opportunity, and 28% of respondents said that inquiry-based instruction was never covered in their science education coursework.

The factors above could be contributing to the low student achievement scores for West Virginia middle school science students. Lack of prior knowledge of what inquiry-based instruction actually means and consists of could be an issue for West Virginia middle school science teachers (Jeanpierre, 2006). It has been well cited that the confusion surrounding the term inquiry exists among certified teachers and education researchers (Anderson, 2002). Literature supports that sustained professional development is the most effective method to change teachers' beliefs, school culture, and the frequency of use of inquiry-based instruction in the science classroom (Chowdhary et al., 2014; Herrington et al., 2016; Lakin & Wallace, 2015; Lebak, 2015; Marshall et al., 2009; Marshall & Smart, 2013). The lack of certification is of concern in that non-certified teachers may not have the science educational background needed to effectively teach middle school science students. It has been found that under-certified or non-certified teachers can reduce student learning growth scores at a rate of up to 20% per school year (Laczko-Kerr & Berliner, 2002).

Perhaps, an additional contributing factor is that many of the respondents of this study disagreed that they felt comfortable in their ability to create inquiry-based instruction that aligns with the Next Generation Science Content Standards and Objectives. Results also revealed that many respondents disagreed that the WV Next Generation Science Content Standards and Objectives were effective guidelines for the implementation of inquiry-based instruction. These results indicate that many of our middle school science teacher respondents perceive they have not received adequate training on the standards. The West Virginia Department of Education may have done a poor job on training science teachers on the new Next Generation Science Content Standards and Objectives. The preparation level of teachers, specifically new teachers and uncertified teachers has been shown to affect levels of attrition (Darling-Hammond, 2003). Specifically, “first-year teachers who feel they are well prepared… on such items as preparation in planning lessons, using a range of instructional methods, and assessing students, two-thirds of those reporting strong preparation intend to stay as compared to only one-third of those reporting weak preparation” (Darling-Hammond, 2003, p. 8). Continuity and commitment to teaching strengthens a school’s curriculum program as teachers’ teaching skills have been shown to sharply increase after the first few years of teaching (Darling-Hammond, 2003). The West Virginia Department of Education should commit to supporting new teachers through professional development and trainings in order to increase student achievement and high-quality teaching.

Overall, teachers’ perceptions from the survey did shed a positive light on middle school science in that it appears teachers want to use inquiry-based instruction and know that it is the preferred and recommended method. Questions arise from the results, such as: are most middle school teachers self-taught in the process of using inquiry-based instruction and have they received adequate training in regard to the use of inquiry-based instruction to address their state content standards? State departments of education should continue to develop and hone science standards that call for the use of inquiry-based instruction in all grade levels. In addition, either state or county education officials should offer more sustained professional development opportunities to middle school science teachers in the area of inquiry-based instruction. Non-certified and less experienced middle school science teachers could be paired with certified and experienced mentor science teachers to help address any deficiencies that may exist in the use of effective inquiry-based science teaching strategies.

Extent of Use of Inquiry-Based Instruction

The data of this study revealed West Virginia middle school science teachers use multiple inquiry-based instructional strategies in their middle school classrooms. The amount of yes responses in regard to participant use of the 11 listed inquiry-based instructional strategies far outnumbered the no responses, with only 72 no responses out of 627 total responses.

Only two strategies rated below an 80% yes response: *Engaging in Argument from Evidence* and *Mathematical and Computational Thinking.* Do the content standards for middle school science not encourage mathematical and computational thinking and engaging in argument from evidence? Analysis of the *Next Generation Content Standards and Objectives* for grades six, seven, and eight negate this thought (West Virginia Board of Education, 2015). Perhaps, mathematical and computational thinking and engaging in argument from evidence seem too difficult for this student age group since they engage higher-order thinking skills and prior knowledge. The *West Virginia College and Career Readiness Standards for ELA and*

Mathematics suggest otherwise (West Virginia Board of Education, 2016). In fact, the standards state that students should engage in argumentative writing 35% of the time. Engaging in Argument from Evidence correlates directly with argumentative writing and could be a cross-curricular benefit for middle school science and English language arts students. Mathematical and Computational Thinking could also be used more regularly in the middle school science classroom and benefit students in their mathematics course work. State assessments focus primarily on mathematics and English language arts so the use of both of the inquiry-based instructional strategies that ranked the lowest is essential for the academic success of West Virginia students.

Perhaps the avoidance of the use of these strategies lies with the middle school science teachers' personal preferences or lack of knowledge on how to best use these strategies to effectively and efficiently teach science (Dolan & Grady, 2010; Wayne & Youngs, 2003). Teacher confidence in content knowledge and inquiry-based instructional strategies is an essential component for effective teaching and learning (Marzano, 2001). Another possibility is middle school students' maturity and ability levels. Often, teachers are teaching overcrowded classes with students of varying abilities, often without assistance (Chan, 2008; Mascil, 2014). These higher-order thinking strategies may seem overwhelming to undertake during a short class period with students of varying ability levels. In addition, teachers may feel pressured to quickly cover content in order to address all standards and feel these two strategies, *Mathematical and Computational Thinking* and *Engaging in Argument from Evidence*, require large amounts of class time to master and complete (Sproken-Smith, Walker, Batchelor, O'Steen, & Angelo, 2011).

Also, perhaps a better way to have sought true extent of use in inquiry-based instructional strategies would have been to ask participants to list or choose the number of times they use each strategy per topic unit, grading period, semester, or year. In addition, seeking qualitative answers could have revealed more detail in extent of use. Participants may have been asked to list examples of the way they used each strategy to provide more useful data for the study.

Supports & Barriers of Inquiry-Based Instruction

Supports that promote the use of inquiry-based instruction are imperative to create an effective science program at any grade level. The data revealed that administrative support of inquiry-based instruction was one prominent factor. Administrators through the use of walkthroughs, Professional Learning Communities (PLCs), observations, and evaluations could influence and motivate teachers to use more inquiry-based instruction. State and county-level support of inquiry-based instruction were also perceived to be strong factors of support. Logically, these data make sense due to inquiry-based instruction being the preferred and recommended form of science instruction (National Research Council, 2013). The perception that West Virginia middle school teachers have in regard to administrative support of inquiry-based instruction is particularly important since non-supportive administration was found to be one of three top reasons teachers, at the national level, provide for not using inquiry-based instruction (Johnson, 2006). Respondents from this study said "Administration (both school & county level) are highly supportive of and encourage the use of IBI" and, "The principal pushes for inquiry-based lessons." These and other positive affirmations from 19 respondents from this study imply that administrators recognize and impress the importance of inquiry-based instruction in the middle school science classroom.

In addition, the data imply that West Virginia middle school science teachers from this study know the Next Generation Science Content Standards and Objectives call for the use of inquiry to address the standards and facilitate learning (West Virginia Board of Education, 2015). Perhaps, further educating administrators on the benefits of the use of inquiry-based education could enhance and amplify the use of inquiry in middle school science classrooms. Offering trainings on the use of the Next Generation Science Content Standards and Objectives could be of benefit, especially for new and uncertified middle school science teachers. Perhaps, through the use of inquiry-based instruction that aligns with the standards, middle school science achievement scores for standardized tests may increase.

Student enjoyment and engagement during the use of inquiry-based instruction was also strongly agreed upon as a form of teacher support. Additionally, in the Likert scale statements many respondents disagreed that student misbehavior and student management occurred during the use of inquiry-based instruction. As previously reviewed in the literature, student engagement has been directly linked to both science student achievement increases and increased student interest in science fields (Bredderman, 1983). Teachers can use inquiry-based instruction to help motivate their students to potentially enter science fields in the future, due to teacher activity being a strong determinant in student interest (Gibson & Chase, 2002). In addition, engaged and happy students could lead to higher job satisfaction for teachers and could lead to more teachers staying in the field of public science education (Lavy & Bocker, 2018). West Virginia middle school science teachers said, “Kids love it!” and listed “Student desire” as motivating forms of support to use inquiry-based instruction.

Lastly, colleague collaboration was another area that was strongly agreed to be an important form of inquiry-based instruction support. The common use of the team model in middle schools may have contributed to these data findings. In addition, PLCs allow for colleague cross-curricular and departmental collaboration and can lead to school reform and true change. Allowing teachers time to collaborate and build inquiry plans would be a supportive measure that could increase use. Lepareur and Grangeat (2018) found that when science teachers collaborate the use of inquiry-based instruction increases, and the classroom becomes more student-centered in terms of learning. These results also imply that the development of a mentoring system could help increase the use of inquiry-based instruction as could county or state level professional development opportunities for middle school science teachers. (Gejda & LaRocco, 2006; Marshall & Smart, 2013).

Obstacles West Virginia middle school science teachers face when attempting to use inquiry-based instruction in the classroom are numerous. Lack of laboratory supplies topped the list as the most difficult barrier. In addition, student behavior, lack of parent and community support, and the need for more class and planning time were common complaints. Funding must be made a priority at the state-level to make all schools equitable in science education opportunities (Banilower et al., 2013). Currently, West Virginia science funding is solely dependent upon county levy money in some areas. This practice is unfair to West Virginia's students and does not provide a level playing field for the future post-secondary education of many of our students. Perhaps inviting and including more parent and community support in the science classroom could become a resource to alleviate funding issues. Science fairs, open houses, guest speakers, and community sponsors are avenues that science teachers could explore to increase the use of inquiry and gain needed resources for their classrooms.

Student behavior can be challenging during inquiry, but with continuous use and unfaltering teacher expectations many students will begin to comply and become fully engaged in the inquiry process. To simply not use inquiry-based instruction because of disruptive students is inexcusable. Classroom management skills should be focused upon during inquiry-based instruction professional development opportunities and science education course work in order to defeat this obstacle (Mascil, 2014). County level training opportunities on classroom management and instructional strategies could be offered for less experienced or uncertified teachers.

Furthermore, classroom behavior could be linked to overcrowded class rooms. Research suggests that an ideal science classroom should have no more than 24 students to function safely and effectively (National Science Teachers Association, 2014). In a laboratory classroom, lack of space and lack of supplies is especially important in terms of overcrowding. Working in pairs is also a best practice used in science classrooms so that each student is able to fully participate in the activity. Overcrowded classes could inhibit the use of inquiry-based instruction simply due to lack of space for laboratory activities and investigations to occur in a safe and effective manner. Stephenson, West, and Westerlund (2003) and West and Kennedy (2014) found that laboratory accidents increased more than 40% when class size increased from a class size of 20-24 middle school students to greater than 24 students. Sixty-one percent, or 35 out of 57 respondents, of the study had at least one class of greater than 24 students. Class size must be considered in the subject area of science not just for quality one-on-one teacher-student interaction, but also for the basic safety of students.

Lack of time, both class and planning, is a well-known barrier to the use of inquiry-based instruction. Often, laboratory activities and investigations require multiple class periods to complete. Through qualitative data collection, time was frequently mentioned as an issue for West Virginia middle school science teachers. The issue of time can also be linked to multiple classroom components: preparing inquiry-based instruction, setting up laboratory experiments, creating presentations, analyzing data, discussion of the results, and covering content standards. Nationally, time is frequently listed as a major obstacle in the use of full-inquiry in the science classroom (Louden, 1997; Welch, Klopfer, Aikenhead, & Robinson, 1981). Often, lack of time can be an obstacle to teachers attempting to use full-inquiry in a class that ranges from 40-60 minutes per day (Canaday & Rettig, 1995).

Inconsistencies that arose through the data findings are also of concern. Five statements concerning laboratory space, relevant technology, planning time, class time, and class size show mixed perceptions among the respondents in terms of whether these were considered supports or obstacles. Why are there so many inconsistencies across a relatively small population area of six West Virginia counties? Many variables contribute to this issue such as: student population size, funding, county levy support, tax base in the county, number of science teachers per school, structuring of the school day schedule, and technology initiatives. How can the state of West Virginia create an equitable school experience? It seems unfair that many students, and their teachers, perceive these issues as obstacles simply due to lack of funding. This question brings to thought why many people are pro-consolidation in an effort to put all the funding in one school to benefit more students. The West Virginia Department of Education and the central offices within each county should explore all available options to increase the funding and decrease the class size for their middle school classes.

Demographic Relationships to Inquiry-Based Instruction

Demographic relationships to efficacy levels in inquiry-based instruction is a complex topic to explore. This study hoped to determine relationships between efficacy levels and demographics such as certification, number of preps, class times, planning times, exposure to inquiry-based instruction in science education course work, attendance of professional development opportunities, and class size.

The data revealed that respondents lacking middle school science endorsements, teaching only 1 Prep, having less than 5 years science teaching experience, never being exposed to inquiry-based instruction in science education course work, and never attending professional development opportunities consistently chose lower ranks for efficacy level statements. Statements that included comfort levels in the use of inquiry-based instruction, the use of inquiry-based instruction to meet *West Virginia Next Generation Science Content Standards and Objectives* and feeling adequately trained in the use of inquiry-based instruction were frequently ranked lower for the above demographic categories. These results were expected, with the exception of only teaching one grade level, or Prep. Literature cites inexperience, lack of certification, no professional development opportunities, and poor teacher preparation programs as reasons teachers are not confident in their ability to use inquiry-based instruction (Gejda & LaRocco, 2006).

Class times and planning times of greater than 60 minutes also consistently chose lower ranks for the previously mentioned efficacy level statements. In addition, the class and plan time greater than 60 minutes respondents chose lower ranks for comfortableness in creating inquiry-based instruction that align to the state standards and the belief that the standards are effective teacher guidelines for implementing inquiry-based instruction. These results were unexpected since literature says the opposite is true, the more class and planning time a science teacher has the more likely inquiry will be used in the classroom (Louden, 1997; Welch, Klopfer, Aikenhead, & Robinson, 1981). One explanation is that the class and planning times are not being used in an efficient manner or student attention spans are not developed enough to be engaged for 60 minutes or more. Perhaps respondents, in this study, with class and planning times of greater than 60 minutes fall into the other demographic categories associated with lower mean ranks for efficacy such as: less than five years science teaching experience, no middle school science endorsement, no exposure to inquiry-based instruction in science education course work, and never attended a professional development opportunity on inquiry-based instruction.

West Virginia middle school science teachers who attended two or more inquiry-based instruction professional development opportunities chose higher ranks for efficacy level. Survey question 12 stated that teachers believed inquiry-based instruction was the most effective way to teach students science. Significance was achieved in this demographic category. Literature supports these results in that sustained professional development has been found to be the most effective way to increase and maintain the use of inquiry-based instruction in the science classroom (Chowdhary et al., 2014; Herrington, Bancroft, Edwards & Schairer, 2016; Lakin & Wallace, 2015; Lebak, 2015; Marshall, Horton, Igo & Switzer, 2009; Marshall & Smart, 2013;). Educational state leaders and county curriculum directors could increase the amount of professional development opportunities offered and provide funding to allow higher teacher attendance to increase the use of full-inquiry in the middle school science classroom.

Additional Comments

Question 35 asked respondents to list any additional comments they had about inquiry-based instruction. Eleven out of 57 respondents answered at a rate of 19%. When analyzed, four main topics emerged: 1) teacher respondents enjoy using inquiry-based instruction and believe it is essential for science at all grade levels, 2) teacher respondents wish they could use inquiry-based instruction more often, 3) large class sizes with students of varying abilities make the use of inquiry-based instruction difficult and 4) county professional development opportunities on inquiry-based instruction are sparse. While these comments are not all-inclusive of the entire study population, they amplify the findings that the majority of West Virginia middle school science teachers believe inquiry-based instruction is a best practice in science classrooms. Education should be focused on how to best teach a child and to create lasting knowledge and understanding. The National Research Council's (2013) Framework calls for a change in the way American schools treat the teaching of science. A thoughtful discussion and analysis of how to start this change in West Virginia middle schools would be a worthwhile endeavor for our students.

Summary

This research study sought to determine West Virginia middle school science teachers', employed by six counties, perceptions on inquiry-based instruction. The focus of the study was on efficacy level, extent of use, and support and barriers of inquiry-based instruction. The data revealed that the majority of the respondents use inquiry-based instructional strategies and recognize its importance in effectively teaching their students science. Support from administration at the school, county, and state levels was strongly agreed upon. Additionally, colleague collaboration and student enjoyment and engagement were other important factors of support in the use of inquiry-based instruction to West Virginia middle school science teachers. Lack of funding, lack of supplies, lack of planning and class time, and student behavior were considered significant barriers that teachers had to overcome to effectively use inquiry-based instruction.

Demographic variables such as science teaching years of experience, certification status, exposure level to inquiry-based instruction in science education course work, and attendance of professional development opportunities seemed to play a role in how West Virginia middle school science teachers perceived their efficacy level in the use of inquiry in the classroom. The National Research Council's (2013) Framework suggests and recommends that inquiry-based instruction be the primary method of teaching science. Qualitative data further intensified the perception that West Virginia middle school science teachers enjoy using inquiry-based instruction, want to use it more often, and know it is recommended and effective. The qualitative data also brings to the forefront of the discussion the reasons inquiry is not used more often. Barriers such as lack of supplies, lack of time, lack of funding and lack of professional development present areas that should be further examined. Large class sizes, that could increase safety problems during the use of laboratory inquiry, could also play a role in reducing the amount of inquiry-based instruction that is used in West Virginia middle school science classrooms. In addition, the inconsistencies in facilities, funding, class size, planning time and class time that exist from county to county, in this study, should be further explored to hopefully balance out these issues.

Recommendations for Further Research

This research study attempted to investigate the perceptions of 68 West Virginia Middle School science teachers across 26 schools located in six counties. Teachers efficacy level, extent of use, and supports and barriers of inquiry-based instruction were examined. Demographic variables were also considered against both efficacy and extent of use to determine differences. Based on these findings, recommendations for further study include:

1. This research study was limited to West Virginia middle school science teachers in six counties. Further research, with a larger population, may provide additional data,

particularly in an effort to compare demographic variables and extent of use and efficacy levels in inquiry-based instruction.

2. The findings revealed that many West Virginia middle school science teachers of various demographic categories did not feel they received adequate exposure to inquiry-based instruction in science education course work. A future study could investigate the inclusion of inquiry-based instruction in science educator preparation programs. This data could be beneficial for future science teachers and higher education science teacher preparation programs.
3. Attendance of professional development opportunities related to inquiry-based instruction is known to increase the use of inquiry in the science classroom. Respondents of this study that had attended two or more professional development opportunities ranked higher in efficacy of inquiry-based instruction. Further research into professional development and the creation of state and county level professional development opportunities for science teachers may increase the use of inquiry-based instruction in the classroom.
4. Class sizes of West Virginia middle school science teachers in this study were often overcrowded, according to national recommendations of 24 or less students being ideal. In terms of both safety and increased use of inquiry-based instruction, further research into the benefits of capping science class enrollments at the middle school level could provide more data on this issue and benefit future science students in West Virginia.
5. Lack of funding and laboratory supplies were frequently cited as obstacles in the use of inquiry-based instruction by the survey respondents of this study. Research into

equitable and adequate funding of science programs in West Virginia could prove beneficial to future science students and their teachers.

6. Support by administration and colleague collaboration was strongly agreed upon by the respondents of this survey as integral to the use of inquiry-based instruction. Further study, on the use of Professional Learning Communities (PLCs), walkthroughs, and the Team Planning Model may provide insight into why these specific supports are important to science teachers attempting to use inquiry-based instruction.
7. The survey instrument used in this study asked for yes/no responses for the extent of use of inquiry-based instruction question. Conducting a more in-depth, perhaps qualitative, study on how often and in what capacity middle school science teachers are using these strategies would provide more understanding and more meaningful data regarding extent of use.

Concluding Remarks

These findings from the research study provide valuable information for middle school science teachers in West Virginia, higher education science teacher preparation programs, and state departments of education that help create and develop state standards and professional development opportunities. The findings reveal the perceptions of West Virginia middle school science teachers on their use and understanding of inquiry-based instruction and the supports and barriers that exist. This study provides a beginning stage for West Virginia's professional development personnel to help guide the creation of a sustainable professional development program that could potentially increase the use of inquiry-based instruction in middle school science classrooms.

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APPENDIX A

IRB APPROVAL LETTER

MARSHALL UNIVERSITY®

May 11, 2018

Edna Meisel, Ed.D.
Elementary and Secondary Education, MUGC

RE: IRBNet ID# 1235923-1
At: Marshall University Institutional Review Board #2 (Social/Behavioral)

Dear Dr. Meisel:

Protocol Title:	[1235923-1] Teachers' Practices and Perceptions Concerning the Implementation of Inquiry-Based Instruction in Middle School Science	
Site Location:	MUGC	
Submission Type:	New Project	APPROVED
Review Type:	Exempt Review	

In accordance with 45CFR46.101(b)(2), the above study was granted Exempted approval today by the Marshall University Institutional Review Board #2 (Social/Behavioral) Designee. No further submission (or closure) is required for an Exempt study **unless** there is an amendment to the study. All amendments (including the addition of research staff) must be submitted and approved by the IRB Chair/Designee.

This study is for student Jill Wood.

If you have any questions, please contact the Marshall University Institutional Review Board #2 (Social/Behavioral) Coordinator Bruce Day, ThD, CIP at 304-696-4303 or day50@marshall.edu. Please include your study title and reference number in all correspondence with this office.

APPENDIX B

COUNTY SCHOOL SYSTEM PERMISSION LETTER

Dear Superintendent(s),

My name is Jill Wood and I am currently working on my Ed.D. through Marshall University in Curriculum & Instruction with an emphasis in Leadership Studies. I am at the dissertation stage of my program and am writing to ask for your assistance and permission to allow your middle school science teachers, grades 6^{th}-8^{th}, to participate in an online survey via Survey Gizmo. The survey will be provided to middle school science teachers in the RESA I district.

The survey is titled *West Virginia Middle School Science Teacher's Perceptions on Scientific Inquiry-Based Instruction: Confidence, Obstacles & Support*. The survey is online, voluntary, and anonymous and is relevant to the current Next Generation Content Standards and Objectives recommendation that inquiry-based instruction be used in science classrooms. The information obtained will be safely kept and no personal identifying information will be collected in the survey.

My chairperson is Dr. Edna Meisel from Marshall University South Charleston Branch. She and my committee members have reviewed the survey and a pilot survey was conducted in Fayette county middle schools to ensure survey reliability. I would greatly appreciate your permission to conduct this research and any survey results are available for your personal review upon request.

If you have any further questions or need more clarification, please do not hesitate to contact me at jewood@k12.wv.us or 304-376-8446. I am currently a teacher at Independence High School in Raleigh County.

Thanks again and I hope to hear from you soon.

Jill E. Wood

APPENDIX C

CONSENT LETTER

Marshall University IRB

Approved on:	5/11/18
Study number:	1235923

Letter of Consent

You are invited to participate in a research project entitled "*Teachers' Practices and Perceptions Concerning the Implementation of Inquiry-Based Instruction in Middle School Science*" designed to analyze the perceptions of West Virginia middle school science teachers on their use of inquiry-based instruction. Topics of the study address demographic data, inquiry-based instructional strategies, teacher efficacy levels in implementing inquiry-based instruction, and supports and barriers in regard to implementing inquiry-based instruction. The study is being conducted by Dr. Edna Meisel and Jill Wood from Marshall University. This research is being conducted as part of the dissertation requirements for Jill Wood.

This survey is comprised of a paper survey containing 36 questions that will take approximately 15 minutes to complete. Your replies will be anonymous, so do not put your name anywhere on the form. There are no known risks involved with this study. Participation is completely voluntary and there will be no penalty or loss of benefits if you choose to not participate in this research study or to withdraw. If you choose not to participate you may either return the blank survey or you may discard it. You may choose to not answer any question by simply leaving it blank. Returning the survey to your school administrator, county designee, or school designee indicates your consent for use of the answers you supply. If you have any questions about the study you may contact Dr. Edna Meisel at 304-746-8983, Jill E. Wood at 304-376-8446.

If you have any questions concerning your rights as a research participant, you may contact the Marshall University Office of Research Integrity at (304) 696-4303.

By completing this survey and returning it you are also confirming you are 18 years of age of older.

Please keep this page for your records.

APPENDIX D

SURVEY INSTRUMENT

Inquiry-Based Instruction Survey

Please answer the following questions concerning your education and science classroom experiences:

1. Grade Level(s) in which you teach science (circle all that apply):

Sixth Grade   Seventh Grade   Eighth Grade

2. Years of science teaching experience (circle one):

5 years or less   6 – 10 years   11- 15 years   greater than 15 years

3. License certification (circle one):

Middle school science endorsement (i.e., General Science, Earth and Space, Physical Science)   No middle school science endorsement

4. Number of students in your science class(es) (answer all that apply):

a. I teach one science class. Number of students in this class: ___________

b. I teach more than one science class. The number of students in each class:

Class #1: _______   Class #4 _______
Class #2: _______   Class #5 _______
Class #3: _______   Class #6 _______

5. Classroom time (answer one and add information where needed):

a. I teach one science class. The amount of time for this class is: ___________
b. I teach more than one science class. The amount of time for each class is:

Class #1: _______   Class #4 _______
Class #2: _______   Class #5 _______
Class #3: _______   Class #6 _______

6. Planning time (answer one and add information when needed):

a. I have no planning time.
b. I have one planning time. The amount of time for this is: ___________
c. I have more than one planning time. The amount of time for each is:

Planning #1: _______   Planning #2: _______   Planning #3: _______

Inquiry-based instruction for this survey is defined as the use of laboratory experiments, building models that represent real-world phenomena and/or structures, and using problem-solving to investigate real-world problems through the science curriculum.

7. Was teaching by using inquiry-based instruction covered in your professional education courses (circle all that apply)?

Bachelor's course work   Master's course work   Not covered in my course work

8. Have you ever attended a professional development workshop or program that covered the use of inquiry-based instruction (circle one)?

Yes, I have attended 1   Yes, I have attended 2 or more   Have not attended

Please mark either yes or no concerning your use of the following inquiry-based strategies.

9. I use the following forms of inquiry-based instructional strategies in my science classes:		
	Yes	No
Developing Models		
Analysis and Interpretation of Data		
Mathematical and Computational Thinking		
Engaging in Argument from Evidence		
Defining Problems		
Designing a Solution		
Active Inquiry		
Investigations		
Hands-on Activities		
Laboratory Skills		
Laboratory Safety		

Please answer the following questions concerning the use of inquiry-based instruction in your middle school science classroom.

Please check one option for each statement listed below.	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree
10. I feel comfortable using inquiry-based instruction in my middle school science classes.						
11. I use inquiry-based instruction to ensure I address all required WV Next Generation Science Standards in my science classes.						
12. I believe using inquiry-based instruction is the most effective way to teach my students science.						
13. I feel I received adequate training about using inquiry–based instruction in my science education courses.						
14. I believe my students learn science better when I use inquiry-based instruction than when I use lecture and text-based instruction.						
15. I believe my students learn science better when I use lecture and text-based instruction than when I use inquiry-based instruction.						
16. I believe my students learn science better when I use both inquiry-based instruction and lecture and text-based instruction.						
17. I feel comfortable in my ability to create inquiry-based instruction that aligns to WV Next Generation Science Standards.						
18. The WV Next Generation Science Standards are effective teacher guidelines for the implementation of inquiry-based instruction.						
19. I have enough laboratory supplies to support the implementation of inquiry-based instruction in my science classes.						
20. I have enough laboratory space to safely and effectively support the use of inquiry-based instruction in my science classes.						
21. I have enough relevant technology to effectively implement inquiry-based instruction in my science classes.						
22. I have enough planning time to support the implementation of inquiry-based instruction in my science classes.						
23. I have enough teaching time to support the implementation of inquiry-based instruction in my science classes.						

Please check one option for each statement listed below.	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree
24. Inquiry-based instruction is supported by my students' level of enjoyment and engagement in science class.						
25. Implementing inquiry-based instruction prepares my students for state standardized assessments.						
26. My class size is appropriate for the use of inquiry-based instruction.						
27. My principal/school administration supports the use of inquiry-based instruction.						
28. I have parent and/or community participation that supports the implementation of inquiry-based instruction.						
29. My county central office supports the use of inquiry-based instruction.						
30. The WV Department of Education supports the use of inquiry-based instruction.						
31. Students are often off-task during inquiry-based instruction.						
32. Students are difficult to manage when I use inquiry-based instruction activities.						

33. Please list the most important form(s) of support you receive that allows you to use inquiry-based instruction.

34. Please list the most difficult barrier(s) you encounter that prevent you from using inquiry-based instruction.

35. Please add any other comments you have concerning inquiry-based instruction.

APPENDIX E

COMPLETE LIST OF DATA TABLES

Table E1

Teachers' Perceptions of their Efficacy Level in Inquiry- Based Instruction Methods

	Frequency of responses and percentage (n = 57 participants for each question)							
Survey Question	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Chi^2 Obtained Value	Probability level attained
Q10 Comfortable using IBI	0 (0%)	2 (3.51%)	1 (1.75%)	10 (17.54%)	15 (26.32%)	29 (50.88%)	45.719	.000*
Q11 Using IBI addresses WV NGCSO	2 (3.51%)	1 (1.75%)	0 (0%)	9 (15.79%)	19 (33.33%)	26 (45.61%)	41.509	.000*
Q12 Using IBI is most effective method	0 (0%)	0 (0%)	5 (8.77%)	10 (17.54%)	22 (38.60%)	20 (35.09%)	13.807	.003*
Q13 Received adequate IBI training in science education courses	5 (8.77%)	9 (15.79%)	8 (14.04%)	14 (24.56%)	12 (21.05%)	9 (15.79%)	5.211	.391
Q14 Students learn better using IBI vs Lecture/Text	0 (0%)	0 (0%)	6 (10.53%)	11 (19.30%)	20 (35.09%)	20 (35.09%)	10.158	.017*
Q15 Students learn better using Lecture/Text vs IBI	8 (14.04%)	19 (33.33%)	17 (29.82%)	5 (8.77%)	7 (12.28%)	1 (1.75%)	26.053	.000*
Q16 Students learn better using both IBI & Lecture/Text	0 (0%)	1 (1.75%)	1 (1.75%)	5 (8.77%)	16 (28.07%)	34 (59.65%)	69.228	.000*
Q17 Comfortable creating IBI aligned with WV NGCSO	1 (1.75%)	4 (7.02%)	4 (7.02%)	16 (28.07%)	20 (35.09%)	12 (21.05%)	30.684	.000*
Q18 WV NGCSO are effective guidelines for IBI	2 (3.51%)	5 (8.77%)	6 (10.53%)	16 (28.07%)	18 (31.58%)	10 (17.54%)	21.421	.001*

*Significance attained at the $p<0.05$ level.

Table E2
Teachers' Perceptions of their Extent of Use of Inquiry-Based Instruction Methods

Method	Frequency of responses and percentage (n = 57 participants for each method) Yes	No	Chi^2 Obtained Value	Probability level attained
Developing Models	53 (93%)	4 (7%)	42.123	.000*
Analysis/Interpretation Data	51 (89%)	6 (11%)	35.526	.000*
Math/Computational Thinking	43 (75%)	14 (25%)	14.754	.000*
Engaging in Argument From Evidence	40 (70%)	17 (30%)	9.281	.000*
Defining Problems	49 (86%)	8 (14%)	29.491	.000*
Designing a Solution	50 (88%)	7 (12%)	32.439	.000*
Active Inquiry	48 (84%)	9 (16%)	26.684	.000*
Investigations	56 (98%)	1 (2%)	53.070	.000*
Hands-on Activities	56 (98%)	1 (2%)	53.070	.000*
Lab Skills	51 (89%)	6 (11%)	35.526	.000*
Lab Safety	54 (95%)	3 (5%)	45.632	.000*

*Significance attained at the p<0.01 level.

Table E3
Teachers' Perceptions of Supports & Obstacles in the Use of Inquiry-Based Instruction

Survey Question	Frequency of responses and percentage (n = 57 participants for each question) Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree	Chi^2 Obtained Value	Probability level attained
Q19 Enough lab supplies to use IBI	16 (28.07%)	11 (19.30%)	9 (15.79%)	13 (22.81%)	6 (10.53%)	2 (3.51%)	13.211	.021*
Q20 Enough lab space to use IBI	12 (21.05%)	8 (14.04%)	9 (15.79%)	9 (15.79%)	8 (14.04%)	11 (19.30%)	1.421	.922
Q21 Enough technology to use IBI	9 (15.79%)	8 (14.04%)	4 (7.02%)	14 (24.56%)	13 (22.81%)	9 (15.79%)	6.895	.229
Q22 Enough planning time to use IBI	8 (14.04%)	8 (14.04%)	8 (14.04%)	11 (19.30%)	14 (24.56%)	8 (14.04%)	3.316	.651
Q23 Enough class time to use IBI	9 (15.79%)	4 (7.02%)	7 (12.28%)	13 (22.81%)	16 (28.07%)	8 (14.04%)	9.842	.080
Q24 Student's enjoyment & engagement in IBI	0 (0%)	0 (0%)	1 (1.75%)	12 (21.05%)	24 (42.11%)	20 (35.09%)	21.667	.000*
Q25 IBI Prepares students for Standardized Testing	4 (7.02%)	7 (12.28%)	0 (0%)	17 (29.82%)	17 (29.82%)	12 (21.05%)	12.035	.017*
Q26 Class Size supports IBI	1 (1.75%)	8 (14.04%)	13 (22.81%)	11 (19.30%)	13 (22.81%)	11 (19.30%)	10.895	.054
Q27 Admins support IBI	0 (0%)	0 (0%)	1 (1.75%)	4 (7.02%)	16 (28.07%)	36 (63.16%)	53.105	.000*
Q28 Parents/Community support the use of IBI	12 (21.05%)	7 (12.28%)	4 (7.02%)	16 (28.07%)	13 (22.81%)	5 (8.77%)	12.368	.030*
Q29 Central Office supports IBI	2 (3.51%)	6 (10.53%)	0 (0%)	12 (21.05%)	16 (28.07%)	21 (36.84%)	20.281	.000*
Q30 WVDE supports use of IBI	2 (3.51%)	1 (1.75%)	7 (12.28%)	10 (17.54%)	14 (24.56%)	23 (40.35%)	35.526	.000*
Q31 Students off-task with use of IBI	14 (24.56%)	8 (14.04%)	4 (7.02%)	24 (42.11%)	6 (10.53%)	1 (1.75%)	36.579	.000*
Q32 Difficulty with student management	13 (22.81%)	10 (17.54%)	11 (19.30%)	15 (26.32%)	7 (12.28%)	1 (1.75%)	13.000	.023*

*Significance attained at the $p<0.05$ level.

Table E4
Certification Endorsement

Certification	Middle School Endorsement Mean Rank (n = 40)	No Middle School Endorsement Mean Rank (n = 17)	Mann-Whitney U Obtained Value	Probability level attained
	(n = 57 participants for each question)			
Q10 Comfortable using IBI	32.25	21.35	210.0	.014*
Q11 Using IBI addresses WV NGCSO	32.11	21.68	215.5	.019*
Q12 Using IBI is most effective method	30.21	26.15	294.5	.371
Q13 Received adequate IBI training in science education courses	32.04	21.85	218.5	.031*
Q14 Students learn better using IBI vs Lecture/Text	28.89	29.26	344.5	.934
Q15 Students learn better using Lecture/Text vs IBI	29.94	26.79	302.5	.498
Q16 Students learn better using both IBI & Lecture/Text	29.64	27.50	314.5	.611
Q17 Comfortable creating IBI aligned with WV NGCSO	32.29	21.26	208.5	.017*
Q18 WV NGCSO effective guidelines for IBI	29.04	28.91	338.5	.978

*Significance attained at the $p<0.05$ level.

Table E5
Class Time

Class Time	59 Minutes or Less Mean Rank (n = 47)	60 Minutes or More Mean Rank (n = 10)	Mann-Whitney U Obtained Value	Probability level attained
	(n = 57 participants for each question)			
Q10 Comfortable using IBI	30.95	19.85	143.5	.037*
Q11 Using IBI addresses WV NGCSO	31.34	18.00	125.0	.013*
Q12 Using IBI is most effective method	30.27	23.05	175.5	.187
Q13 Received adequate IBI training in science education courses	31.40	17.70	122.0	.016*
Q14 Students learn better using IBI vs Lecture/Text	29.21	28.00	225.0	.825
Q15 Students learn better using Lecture/Text vs IBI	30.02	24.20	187.0	.297
Q16 Students learn better using both IBI & Lecture/Text	28.90	29.45	239.5	.914
Q17 Comfortable creating IBI aligned with WV NGCSO	32.14	14.25	87.5	.001*
Q18 WV NGCSO effective guidelines for IBI	32.18	14.05	85.5	.001*

*Significance attained at the $p<0.05$ level.

Table E6
Planning Time

Planning Time	(n = 57 participants for each question) 59 Minutes or Less Mean Rank (n = 38)	60 Minutes or More Mean Rank (n = 29)	Mann-Whitney U Obtained Value	Probability level attained
Q10 Comfortable using IBI	32.21	25.90	316.0	.118
Q11 Using IBI addresses WV NGCSO	34.73	23.47	245.5	.006*
Q12 Using IBI is most effective method	30.96	27.10	351.0	.353
Q13 Received adequate IBI training in science education courses	35.09	23.12	235.5	.006*
Q14 Students learn better using IBI vs Lecture/Text	31.04	27.03	349.0	.339
Q15 Students learn better using Lecture/Text vs IBI	28.07	29.90	432.0	.667
Q16 Students learn better using both IBI & Lecture/Text	29.93	28.10	380.0	.635
Q17 Comfortable creating IBI aligned with WV NGCSO	32.50	25.62	308.0	.104
Q18 WV NGCSO effective guidelines for IBI	32.95	25.19	295.5	.069

*Significance attained at the $p<0.05$ level.

Table E7
Number of Preps

	(n=57 participants for each question)				
Number of Preps	1 Prep Mean Rank (n = 39)	2 Preps Mean Rank (n = 13)	3 Preps Mean Rank (n = 5)	Kruskal-Wallis Obtained Value	Probability level attained
Q10 Comfortable using IBI	25.44	36.00	38.60	6.845	.033*
Q11 Using IBI addresses WV NGCSO	24.51	38.23	40.00	10.490	.005*
Q12 Using IBI is most effective method	27.27	30.31	39.10	2.637	.268
Q13 Received adequate IBI training in science education courses	27.68	31.27	33.40	0.872	.647
Q14 Students learn better using IBI vs Lecture/Text	27.79	31.31	32.40	0.736	.692
Q15 Students learn better using Lecture/Text vs IBI	29.81	28.58	23.80	0.635	.728
Q16 Students learn better using both IBI & Lecture/Text	28.08	29.27	35.50	1.164	.559
Q17 Comfortable creating IBI aligned with WV NGCSO	26.05	37.65	29.50	5.156	.076
Q18 WV NGCSO effective guidelines for IBI	26.58	36.73	27.80	3.915	.141

*Significance attained at the $p<0.05$ level.

Table E8
Professional Development Attendance

	(n = 57 participants for each question)				
Professional Development	Attended 1 Mean Rank (n = 14)	Attended 2 or More Mean Rank (n = 32)	Attended None Mean Rank (n = 11)	Kruskal-Wallis Obtained Value	Probability level attained
Q10 Comfortable using IBI	26.86	33.48	18.68	8.072	.018*
Q11 Using IBI addresses WV NGCSO	28.04	30.53	25.77	0.851	.653
Q12 Using IBI is most effective method	20.61	34.53	23.59	9.291	.010*
Q13 Received adequate IBI training in science education courses	27.29	35.14	13.32	14.871	.001*
Q14 Students learn better using IBI vs Lecture/Text	25.64	31.30	26.59	1.565	.457
Q15 Students learn better using Lecture/Text vs IBI	29.32	27.72	32.32	0.682	.711
Q16 Students learn better using both IBI & Lecture/Text	28.75	30.50	24.95	1.200	.549
Q17 Comfortable creating IBI aligned with WV NGCSO	31.93	30.98	19.50	4.862	.088
Q18 WV NGCSO effective guidelines for IBI	29.86	28.80	28.50	0.055	.973

*Significance attained at the $p<0.05$ level.

Table E9
Years of Science Teaching Experience

(n = 57 participants for each question)

Years of Science Teaching	5 Years or Less Mean Rank (n = 20)	6 – 10 Years Mean Rank (n = 12)	11-15 Years Mean Rank (n = 14)	Greater than 15 Years Mean Rank (n = 11)	Kruskal-Wallis Obtained Value	Probability level attained
Q10 Comfortable using IBI	23.35	26.00	33.36	37.00	7.373	.061
Q11 Using IBI addresses WV NGCSO	26.23	23.12	33.86	34.27	5.057	.168
Q12 Using IBI is most effective method	23.98	28.17	30.04	37.73	5.550	.136
Q13 Received adequate IBI training in science education courses	20.27	32.12	36.96	31.32	9.732	.021*
Q14 Students learn better using IBI vs Lecture/Text	28.02	24.92	29.61	34.45	2.211	.530
Q15 Students learn better using Lecture/Text vs IBI	30.00	25.79	29.93	29.50	0.617	.893
Q16 Students learn better using both IBI & Lecture/Text	27.68	29.21	29.79	30.18	0.283	.963
Q17 Comfortable creating IBI aligned with WV NGCSO	23.20	27.96	33.36	35.14	5.360	.147
Q18 WV NGCSO effective guidelines for IBI	28.82	28.33	26.39	33.36	1.200	.753

Table E10

Exposure to Inquiry Based Instruction during Science Education Course Work

(n=57 participants for each question)

Course Work	Once Mean Rank (n = 31)	Twice Mean Rank (n = 10)	Never Mean Rank (n = 16)	Kruskal-Wallis Obtained Value	Probability level attained
Q10 Comfortable using IBI	29.78	32.65	24.90	1.740	.419
Q11 Using IBI addresses WV NGCSO	29.45	33.55	25.00	1.905	.386
Q12 Using IBI is most effective method	28.52	29.60	29.63	0.070	.966
Q13 Received adequate IBI training in science education courses	32.00	41.45	14.30	19.109	.000*
Q14 Students learn better using IBI vs Lecture/Text	27.22	32.40	30.53	1.012	.603
Q15 Students learn better using Lecture/Text vs IBI	29.50	30.85	26.70	0.474	.789
Q16 Students learn better using both IBI & Lecture/Text	29.69	26.95	28.90	0.272	.873
Q17 Comfortable creating IBI aligned with WV NGCSO	28.61	38.50	23.50	5.342	.069
Q18 WV NGCSO effective guidelines for IBI	28.17	32.00	28.77	0.436	.804

*Significance attained at $p<0.05$ level.

Table E11
Class Size

	(n=57 participants for each question)			
	24 students or less Mean Rank (n = 22)	More than 24 students Mean Rank (n = 35)	Mann-Whitney U Obtained Value	Probability level attained
Q10 Comfortable using IBI	27.91	29.69	409.00	.669
Q11 Using IBI addresses WV NGCSO	26.75	30.41	434.5	.383
Q12 Using IBI is most effective method	25.16	31.41	469.5	.143
Q13 Received adequate IBI training in science education courses	31.95	27.14	320.0	.278
Q14 Students learn better using IBI vs Lecture/Text	23.64	32.37	503.0	.042 *
Q15 Students learn better using Lecture/Text vs IBI	30.84	27.84	344.5	.492
Q16 Students learn better using both IBI & Lecture/Text	27.70	29.81	413.5	.593
Q17 Comfortable creating IBI aligned with WV NGCSO	29.50	28.69	374.0	.851
Q18 WV NGCSO effective guidelines for IBI	24.80	31.64	477.5	.118

*Significance attained at the $p<0.05$ level.

Table E12

Number of Preps and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
1 prep	35	4	1.985	.371	.699
2 preps	13	0			
3 preps	5	0			
Analysis and Interpretation of Data					
1 prep	34	5	.917	.632	1.000
2 preps	12	1			
3 preps	5	0			
Mathematical and Computational Thinking					
1 prep	28	11	.926	.629	.698
2 preps	11	2			
3 preps	4	1			
Engaging in Argument from Evidence					
1 prep	26	13	1.772	.412	.514
2 preps	11	2			
3 preps	3	2			
Defining Problems					
1 prep	33	6	.895	.639	1.000
2 preps	11	2			
3 preps	5	0			
Designing a Solution					
1 prep	33	6	1.303	.521	.830
2 preps	12	1			
3 preps	5	0			
Active Inquiry					
1 prep	32	7	1.076	.584	.725
2 preps	11	2			
3 preps	5	0			
Investigations					
1 prep	38	1	.470	.791	1.000
2 preps	13	0			
3 preps	5	0			
Hands-on Activities					
1 prep	38	1	.470	.791	1.000
2 preps	13	0			
3 preps	5	0			
Laboratory Skills					
1 prep	34	5	.917	.632	1.00
2 preps	12	1			
3 preps	5	0			
Laboratory Safety					
1 prep	36	2	1.462	.482	.349
2 preps	13	2			
3 preps	5	1			

* Significance attained at $p<0.05$.

** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

Table E13

Years of Science Teaching and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
5 years or less	19	1	.229	.973	1.000
6 – 10 years	11	1			
11 – 15 years	13	1			
> 15 years	10	1			
Analysis and Interpretation of Data					
5 years or less	16	4	5.327	.149	.156
6 – 10 years	10	2			
11 – 15 years	14	0			
> 15 years	11	0			
Mathematical and Computational Thinking					
5 years or less	15	5	3.620	.306	.279
6 – 10 years	8	4			
11 – 15 years	13	1			
> 15 years	7	4			
Engaging in Argument from Evidence					
5 years or less	13	7	2.244	.523	.534
6 – 10 years	7	5			
11 – 15 years	11	3			
> 15 years	9	2			
Defining Problems					
5 years or less	14	6	6.958	.073	.098
6 – 10 years	12	0			
11 – 15 years	13	1			
> 15 years	10	1			
Designing a Solution					
5 years or less	16	4	2.942	.401	.493
6 – 10 years	12	0			
11 – 15 years	12	2			
> 15 years	10	1			
Active Inquiry					
5 years or less	16	4	2.191	.534	.570
6 – 10 years	9	3			
11 – 15 years	13	1			
> 15 years	10	1			
Investigations					
5 years or less	19	1	1.883	.597	1.000
6 – 10 years	12	0			
11 – 15 years	14	0			
> 15 years	11	0			
Hands-on Activities					
5 years or less	19	1	1.883	.597	1.000
6 – 10 years	12	0			
11 – 15 years	14	0			

> 15 years	11	0			
Laboratory Skills					
5 years or less	17	3	2.818	.421	.387
6 – 10 years	11	1			
11 – 15 years	14	0			
> 15 years	9	2			
Laboratory Safety					
5 years or less	18	2	2.668	.446	.520
6 – 10 years	12	0			
11 – 15 years	14	0			
> 15 years	10	1			

* Significance attained at $p<0.05$.

** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

Table E14
Certification and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
Middle School Endorsement	37	3	.048	.827	1.000
No Middle School Endorsement	16	1			
Analysis and Interpretation of Data					
Middle School Endorsement	37	3	1.304	.253	.349
No Middle School Endorsement	14	3			
Mathematical and Computational Thinking					
Middle School Endorsement	32	8	1.506	.220	.314
No Middle School Endorsement	11	6			
Engaging in Argument from Evidence					
Middle School Endorsement	29	11	.346	.556	.547
No Middle School Endorsement	11	6			
Defining Problems					
Middle School Endorsement	35	5	.262	.609	.684
No Middle School Endorsement	14	3			
Designing a Solution					
Middle School Endorsement	36	4	.648	.421	.415
No Middle School Endorsement	14	3			
Active Inquiry					
Middle School Endorsement	33	7	.295	.587	.710
No Middle School Endorsement	15	2			
Investigations					
Middle School Endorsement	40	0	2.395	.122	.298
No Middle School Endorsement	16	1			
Hands-on Activities					
Middle School Endorsement	40	0	2.395	.122	.298
No Middle School Endorsement	16	1			
Laboratory Skills					
Middle School Endorsement	38	2	4.349	.037	.058
No Middle School Endorsement	13	4			

Laboratory Safety					
Middle School Endorsement	40	0	7.451	.006	.023 *
No Middle School Endorsement	14	3			

* Significance attained at p<0.05.
** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

Table E15
Number of Students and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
24 or Less Students	19	3	2.405	.121	.288
More than 24 Students	34	1			
Analysis and Interpretation of Data					
24 or Less Students	21	1	1.361	.243	.389
More than 24 Students	30	5			
Mathematical and Computational Thinking					
24 or Less Students	17	5	.065	.799	1.000
More than 24 Students	26	9			
Engaging in Argument from Evidence					
24 or Less Students	15	7	.068	.794	1.000
More than 24 Students	25	10			
Defining Problems					
24 or Less Students	20	2	.736	.394	.466
More than 24 Students	29	6			
Designing a Solution					
24 or Less Students	20	2	.338	.561	.695
More than 24 Students	30	5			
Active Inquiry					
24 or Less Students	17	5	1.297	.255	.286
More than 24 Students	31	4			
Investigations					
24 or Less Students	22	0	.640	.424	1.000
More than 24 Students	34	1			
Hands-on Activities					
24 or Less Students	22	0	.640	.424	1.000
More than 24 Students	34	1			
Laboratory Skills					
24 or Less Students	19	3	.368	.544	.667
More than 24 Students	32	3			
Laboratory Safety					
24 or Less Students	22	0	1.990	.158	.276
More than 24 Students	32	3			

* Significance attained at $p<0.05$.
** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

Table E16
Class Time and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
59 minutes or less	43	4	.915	.339	1.000
60 minutes or more	10	0			
Analysis and Interpretation of Data					
59 minutes or less	41	6	1.427	.232	.577
60 minutes or more	10	0			
Mathematical and Computational Thinking					
59 minutes or less	37	10	1.560	.212	.240
60 minutes or more	6	4			
Engaging in Argument from Evidence					
59 minutes or less	37	10	9.353	.002	.005 *
60 minutes or more	3	7			
Defining Problems					
59 minutes or less	42	5	2.562	.109	.137
60 minutes or more	7	3			
Designing a Solution					
59 minutes or less	42	5	.671	.413	.594
60 minutes or more	8	2			
Active Inquiry					
59 minutes or less	39	8	.306	.580	1.000
60 minutes or more	9	1			
Investigations					
59 minutes or less	46	1	.217	.642	1.000
60 minutes or more	10	0			
Hands-on Activities					
59 minutes or less	46	1	.217	.642	1.000
60 minutes or more	10	0			
Laboratory Skills					
59 minutes or less	42	5	.004	.952	1.000
60 minutes or more	9	1			
Laboratory Safety					
59 minutes or less	44	3	.674	.412	1.000
60 minutes or more	10	0			

* Significance attained at $p<0.05$
** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

Table E17

Plan Time and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
59 minutes or less	27	1	1.002	.317	.611
60 minutes or more	26	3			
Analysis and Interpretation of Data					
59 minutes or less	24	4	.826	.363	.423
60 minutes or more	27	2			
Mathematical and Computational Thinking					
59 minutes or less	21	7	.006	.940	---
60 minutes or more	22	7			
Engaging in Argument from Evidence					
59 minutes or less	20	8	.041	.839	---
60 minutes or more	20	9			
Defining Problems					
59 minutes or less	24	4	.003	.957	1.000
60 minutes or more	25	4			
Designing a Solution					
59 minutes or less	25	3	.125	.723	1.000
60 minutes or more	25	4			
Active Inquiry					
59 minutes or less	23	5	.177	.674	.730
60 minutes or more	25	4			
Investigations					
59 minutes or less	28	0	.983	.322	1.000
60 minutes or more	28	1			
Hands-on Activities					
59 minutes or less	28	0	.983	.322	1.000
60 minutes or more	28	1			
Laboratory Skills					
59 minutes or less	25	3	.002	.964	1.000
60 minutes or more	26	3			
Laboratory Safety					
59 minutes or less	26	2	.390	.532	.611
60 minutes or more	28	1			

* Significance attained at $p<0.05$.

** Fisher's Exact Test probability used in tests where expected cells contained expected count less than 5.

Table E18

Course Work and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
Once	30	2	1.701	.427	.623
Twice	10	0			
Never	13	2			
Analysis and Interpretation of Data					
Once	30	2	2.054	.358	.363
Twice	9	1			
Never	12	3			
Mathematical and Computational Thinking					
Once	22	10	4.064	.131	.123
Twice	10	0			
Never	11	4			
Engaging in Argument from Evidence					
Once	21	11	2.283	.319	.409
Twice	9	1			
Never	10	5			
Defining Problems					
Once	29	3	2.695	.260	.331
Twice	9	1			
Never	11	4			
Designing a Solution					
Once	29	3	1.129	.569	.562
Twice	9	1			
Never	12	3			
Active Inquiry					
Once	24	8	4.856	.088	.155
Twice	10	0			
Never	14	1			
Investigations					
Once	32	0	2.850	.241	.438
Twice	10	0			
Never	14	1			
Hands-on Activities					
Once	32	0	2.850	.241	.438
Twice	10	0			
Never	14	1			
Laboratory Skills					
Once	30	2	5.947	.051	.089
Twice	10	0			
Never	11	4			
Laboratory Safety					
Once	31	1	2.808	.246	.242
Twice	10	0			
Never	13	2			

* Significance attained at $p<0.05$.

** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

Table E19

Professional Development and Use of Inquiry-Based Instruction Strategies (n = 57 participants for each question)

	Yes	No	Chi^2 Obtained Value	** Chi^2 Probability Level Attained	**Fischer's Exact Test Probability Level Attained
Developing Models					
Attended 1	13	1	1.103	.576	.806
Attended 2 or more	29	3			
Never Attended	11	0			
Analysis and Interpretation of Data					
Attended 1	14	0	4.967	.083	.092
Attended 2 or more	29	3			
Never Attended	8	3			
Mathematical and Computational Thinking					
Attended 1	10	4	4.092	.129	.109
Attended 2 or more	27	5			
Never Attended	6	5			
Engaging in Argument from Evidence					
Attended 1	9	5	2.482	.289	.281
Attended 2 or more	25	7			
Never Attended	6	5			
Defining Problems					
Attended 1	11	3	3.839	.147	.097
Attended 2 or more	30	2			
Never Attended	8	3			
Designing a Solution					
Attended 1	12	2	3.428	.180	.145
Attended 2 or more	30	2			
Never Attended	8	3			
Active Inquiry					
Attended 1	12	2	.072	.965	1.000
Attended 2 or more	27	5			
Never Attended	9	2			
Investigations					
Attended 1	14	0	.795	.672	1.000
Attended 2 or more	31	1			
Never Attended	11	0			
Hands-on Activities					
Attended 1	14	0	.795	.672	1.000
Attended 2 or more	31	1			
Never Attended	11	0			
Laboratory Skills					
Attended 1	13	1	.900	.638	.710
Attended 2 or more	29	3			
Never Attended	9	2			
Laboratory Safety					
Attended 1	13	1	.716	.699	.406
Attended 2 or more	31	1			
Never Attended	10	1			

*Significance attained at $p<0.05$ level.

** Fisher's Exact Test probability used because for all tests some expected cells contained expected count less than 5.

APPENDIX F
VITA

Jill E. Wood

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Objective: Obtain a position that incorporates curriculum & instruction, leadership, and technology within an educational setting.

Education:

- Doctorate in Education — Currently Obtaining
  Curriculum & Instruction/Educational Leadership
  Principal Certification Program
  Marshall University Graduate College
  GPA: 3.92

- School Principalship Certificate — August 2015
  Marshall University Graduate College
  GPA: 4.0

- Education Specialist — December 2014
  Curriculum & Instruction
  Marshall University Graduate College
  GPA: 3.92

- Master of Arts in Secondary Education — May 2002
  West Virginia University
  GPA: 3.46

- Bachelor of Science in Environmental Protection — May 1998
  West Virginia University
  GPA: 3.34

Career-Related Experience:

- **Teacher** — Aug 2016-current
  Independence High
  Biology
  Dual Credit Biology 2—Marshall University

- **Virtual Homebound Science Teacher** — July 2015-Aug 2016
  Raleigh County Schools
  Science 6, 7, 8
  Physical Science

Biology
Environmental Earth Science

- **Teacher** Aug 2012-June 2015
  Independence High
  Biology/Biology 2

- **Instructor** Spring 2014
  Marshall University Graduate College
  Co-Taught Online Education Course in Technology
  Dr. Lisa Heaton

- **Teacher**
  Woodrow Wilson High Aug 2011-May 2012
  Biology

- **Teacher** Feb 2009-June 2011
  Valley High School, Smithers, WV
  Human Anatomy & Physiology, Biology

- **Teacher** Aug 2006-June 2007
  Summers County High School, Hinton, WV
  Human Anatomy & Physiology, Advanced Bio & CATS 9

- **Adjunct Professor** Aug 2007-Dec 2007
  Concord University, Athens, WV
  Natural Sciences 414-C

- **Teacher** Aug 2004-June 2006
  University & Morgantown High Schools, Morgantown, WV
  CATS 9 and CATS 10

- **Teacher** Aug 2003-June 2004
  Petersburg High School, Petersburg, WV
  CATS 7
  Performed home-bound teaching duties throughout the year

- **WVU Lab Teaching Assistant** Aug 2001-May 2002
  Forestry Plant Pathology