A STUDY OF TEACHERS' SELF-EFFICACY AND OUTCOME EXPECTANCY

FOR SCIENCE TEACHING THROUGHOUT A SCIENCE INQUIRY-BASED

PROFESSIONAL DEVELOPMENT PROGRAM

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Dissertation

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ABSTRACT

The goal of this study was to investigate the self-efficacies and outcome

expectancies of science teachers over time as a result of their participation in an inquiry-

based, professional development program designed to ensure that all participants are

highly qualified science teachers. Eighty-six teachers participated in inquiry-based

activities designed to increase their content knowledge and teaching expertise while

increasing their science teaching self-efficacies and outcome expectancies of student

learning. This 15-month professional development program included two summer

workshops (summers of 2007 and 2008) with an 8-month classroom implementation

period in between.

A quasi-experimental research design was used to investigate the change in

science teaching efficacy scores after participation in the inquiry-based professional

development program and the relationship of this change with selected independent

variables. The data consisted of (a) three sets of Science Teaching Efficacy Belief

Instrument (Riggs & Enochs, 1990) scores, STEBI-Form A (inservice), reported as a

pretest, posttest, and follow-up posttest; and (b) demographic variables that were used as

covariates: science education background, professional position, number of years taught,

and teacher qualification status in science. Using repeated measures and multiple

regressions with an alpha level of 0.05, and testing the hypothesized changes and relationships, results indicated that there were gains in Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) scores. Of the independent variables, only science education background was found to be a significant contributor toward increasing PSTE ($p = .003$) scores. The other variables were not predictive of gains in either personal science teaching efficacy or science teaching outcome expectancy.

The data gave insight into possible relationships that may exist between science teachers' self-efficacies and outcome expectancies after participation in an inquiry-based professional development program. This study demonstrated the importance of considering interactions between a given set of independent variables and self-efficacy beliefs. The findings also suggested the possible value of considering factors associated with planning long-term programs for teachers' professional development to include the impact of college courses, an implementation period for incorporating the new ideas, support from colleagues and providing professional development to become Highly Qualified Teachers of science.

DEDICATION

I would like to dedicate my work to my precious family, my husband Jay, and my daughters Emily and Grace whose sacrifices and encouragement enabled me to go to school. To my loving parents, who taught me the value of education and instilled in me a love of learning and the values of hard work and persistence.

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have always supported me in everything I do and have always reminded me to see the humor when times were tough.

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CHAPTER I

INTRODUCTION

With the national call for reform of science teaching holding science teachers accountable for the implementation of content standards at all grade levels (K-12), it is imperative that science teachers feel confident in the content knowledge they teach and instructional strategies they employ in the classroom. Authors Rhoton, Bowers, and Shane (2002) state the following:

> Over the past decade, the inability of schools to adequately staff classrooms with highly qualified teachers has increasingly been recognized as a major social problem, has received widespread coverage in the national media, and has been the target of a growing number of reform and policy initiatives. (p. 2)

The reform of science education calls for a commitment to enhance science teaching and learning based on the standards developed by the National Academy of Science's National Research Council (NRC, 1996) in which all students engage in inquiry-based questioning and investigation. Currently, standards-based, educational reform efforts require, ". . . a substantive change in how science is taught; an equally substantive change is needed in professional development practices" (NRC, 1996 p. 560). In order for reform to take place, science teachers need enhanced knowledge, skills, and experiences so that they feel comfortable and have the confidence needed to help their students succeed in learning (Loucks-Horsely, Love, Stiles, Mundry & Hewson, 2003).

Ultimately, teachers have the most direct impact on student learning (Johnson, Kahle & Fargo, 2007b). Student learning depends on teacher knowledge (Loucks-Horsley et al., 2003). Research suggests that teachers' content knowledge and instructional skills are instrumental in the success of their students (Darling-Hammond, 2000). Research has shown large numbers of science teachers who, for various reasons, such as lack of science content background, do not feel prepared to implement the science standards in order for their students to succeed in science (Lumpe, Haney & Czerniak, 2000; Posnanski, 2002). It then becomes the role of professional development providers to understand the teachers' backgrounds and experiences, knowledge and beliefs in order to create a program that will best suit the needs of the teachers and their students (Loucks-Horsley et. al, 2003). Before implementing new professional development programs for teachers, it is necessary to examine the current strengths and weaknesses of the teachers and their schools in order to make improvements in the participating school districts.

In response to the federal No Child Left Behind Law (NCLB) passed in 2006, Ohio passed a Core Law that changed the number of science courses students take in high school. By the year 2011, all high school graduates must complete three credits of science. The three science credits must include one credit of physical science, one credit of biology, and one credit of advanced study. According to the Core Law in Ohio, "Sciences are to include inquiry-based laboratory experiences that engage students in making valid scientific questions and gathering and analyzing information" (Amended Substitute Senate Bill 311, The Ohio Core, Ohio Department of Education, 2007). Teacher qualification standards embedded in the NCLB act require teachers to hold at

least a bachelor's degree, hold licensure in the area of teaching, and show competence in subject knowledge and teaching skills (Onafowora, 2007). The federal government has also instituted a requirement for veteran teachers who possess a grades 1-8 certification and special education teachers to become highly qualified (Appendix C) in their content areas (U.S. Department of Education, 2006).

Will there be enough highly-qualified teachers available to teach all students three years of science? Will the students have enough science content background to pass the Ohio Achievement Tests or the Ohio Graduation Test? In order to be prepared for high school, students need to be successful learners of science in elementary and middle grades (NRC, 1996). Student achievement outcomes and skill acquisition take precedent when preparing science lessons that will help to facilitate future student successes in science (NRC, 1996). In order to successfully prepare our students, science teachers must also be equipped with science content knowledge, self-efficacies, and inquiry pedagogy (Loucks-Horsley et al., 2003). In addition, teachers' beliefs about science, the impact of science teacher quality, and their role in implementing inquiry-based science lessons can be addressed in professional development programs where these issues take priority.

Enochs and Riggs suggest that teachers who believe student learning can be influenced by effective teaching (outcome expectancy beliefs) and who also have confidence in their own teaching abilities (self-efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback when compared to teachers who have lower expectations concerning their own ability (Enochs & Riggs, 1990).

Moss (1997) describes two dimensions of teacher self-efficacy. The first dimension concerns teachers' beliefs with their own ability to influence student behavior. Secondly, the dimension of teachers' beliefs in their own ability to perform specific tasks (level of confidence) (Moss, 1997). For example, a teacher may strongly agree with inquiry implementation in the classroom but doubts his/her ability to design or carry out this type of instruction.

Ramey-Gassert, Shroyer and Staver (1996) conducted a study on the factors that influence science teaching self-efficacy of elementary teachers. They examine factors that influence science teaching efficacy and science teaching outcome expectancy in elementary teachers. They reported that personal science teaching self-efficacy and science teacher outcome expectancy are influenced by positive experiences with high quality science courses, in-service workshops, access to resources, and time as well as supportive peers and administrators.

In order to foster positive changes in science teaching, teachers must learn about, and experience a constructivist approach to science teaching (Joyce & Showers, 1988). Under a constructivist philosophy, professional development for teachers should include learning about science and science teaching via the same methods and strategies that students should learn about science in school (Posnanski, 2002). This study will investigate the impact over time of teachers' self-efficacies and outcome expectancies who will participate in an inquiry-based, hands-on, constructivist professional development program to learn science content. It is hoped that after active participation in this inquiry-based professional development program that provides science inquiry

experiences, the participants will gain content knowledge, increase self-efficacies, and outcome expectancies of student learning.

Purpose of the Study

The purpose of this study was to investigate the self-efficacies and outcome expectancies of science teachers over time as a result of their participation in an inquiry-based, professional development program designed to ensure that all participants are highly qualified science teachers. This inquiry-based professional development program proposed to increase participants' content knowledge, increase their science teaching self-efficacies, and increase their outcome expectancies of student learning. Although content knowledge was part of the professional development program in order for participants to gain the highly qualified teaching status, it was not a variable analyzed in this study. In addition, this study provided professional development providers, teachers, and supervisors with information regarding changes of self-efficacies over time with 8 months of classroom implementation between professional development influence. The results should also be beneficial for educators who are striving to provide quality professional development programs for teachers and their students.

Statement of the Problem

There are many reasons that may explain why elementary school teachers have very little science content knowledge and teaching methods of inquiry. Their college preservice teaching courses were inadequate or few in number. Most elementary teachers take a minimum number of content courses, usually biology and seldom physics in their college program and therefore, they feel inadequate when it comes to mastery of science

content knowledge (Appleton, 2003; Mulholland, Dorman, & Odgers, 2004; Yilmaz & Cavas, 2008). Perhaps they were forced into teaching science because of school restructuring (Kleine et al., 2002). Regardless of the reason, many elementary school teachers believe that they do not have the proper background or knowledge to teach science considering the requirements that standards impose on them and their students (Berns & Swanson, 2000; King, Shumow & Lietz, 2001; Oliver, 1995; Riggs, 1995; Shrigley, 1977; Shrigley, & Johnson, 1974; Windschitl, 2002). Some teachers have low self-efficacies when it comes to teaching science (Enochs, Scharmann & Riggs, 1995; Ghaith & Yaghi, 1997; Haney & Lumpe, 1995; Martin, 2000; Riggs, 1995). Bandura defined self-efficacy as "the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1977a). Teachers' self-efficacies, positive and negative, about teaching science content, are often imitated by the students whom they instruct (Anderson, Green & Loewen, 1988; Ashton & Webb, 1986; Czerniak, Lumpe & Haney, 1999; Enochs & Riggs, 1990; Khourey-Bowers & Simonis, 2004; Ross, 1992). Self-efficacy has been reported to directly impact the teaching pedagogy of science teachers which in turn will ultimately have an impact on student achievement (Brown & Melear, 2006; Hofer & Pintrich, 1999; Johnson, Kahle & Fargo, 2007b; Posnanski, 2002).

This study investigated any changes in science teachers' self-efficacies and outcome expectancies measured by the Science Teaching Efficacy Belief Instrument (STEBI - Form A; Enochs & Riggs, 1990) as a result of teachers' participation in an inquiry-based professional development program. The analysis of the quantitative data supports the notion that a professional development program, which is based on a model

adhering to a constructivist framework, and of 15-month duration that includes participants attending first summer workshop (2007), 8 months of classroom implementation and attending the second summer workshop (2008), can positively influence the science teaching self-efficacy beliefs of the participants (Posnanski, 2002). In addition, this study also contributed to literature related to the effect on teachers' self-efficacies, beliefs, and outcome expectancies on teachers' expectations of student learning as a result of an inquiry-based professional development program.

Research Questions

There are four research questions that address the issue of changing science teachers' self-efficacies and outcome expectancies of students' learning measured over three administrations (pretest, posttest, and follow-up posttest) as a result of an inquiry-based professional development program:

1. Is there a change in self-efficacies measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program?

2. Is there a change in outcome expectancies of students' learning measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program?

3. Is there a relationship between science teachers' self-efficacies measured and science education backgrounds, professional positions, number of years taught, and teacher qualification status in science?

4. Is there a relationship between outcome expectancies of student learning measured and science education backgrounds, professional positions, number of years taught, and teacher qualification status in science?

Significance of the Study

Boling and White (2007) investigated the interactions between preservice teachers and practicing teachers, who were highly qualified, to gain knowledge related to the teaching profession. Boling and White (2007) concluded that both preservice and practicing teachers, "identified self-efficacy as an external concern that influences their ability to be a highly qualified teacher" (p. 53). The most common statement emerging from the participants was the relationship of self-efficacy influencing their ability to be a highly qualified teacher. In addition, they each believed they could improve student achievement based on their teaching expertise. Still, little information is available regarding specific professional development characteristics that directly affect teachers' self-efficacies (Eraut, 1994). Therefore, this study examined, quantitatively, whether there is a relationship between teacher self-efficacy, outcome expectancy of student learning and being a highly qualified teacher of science.

The uniqueness of this study is that the participants have an opportunity to change their self-efficacies and outcome expectancies of student learning by first experiencing inquiry-based science lessons in a professional development program. Then the teachers have the opportunity to reconstruct their belief systems and implement inquiry-based science lessons in their own classrooms. Finally, after one year, the participants revisited

the professional development program to report any changes in self-efficacies and outcome expectancies of student learning.

Assumptions Underlying the Study

Several assumptions underlie this study. First, participants bring numerous and varied self-efficacies and outcome expectancies to students' learning to the professional development program. Second, the instrument being used is assumed to be representative of the variables under investigation; self-efficacies and outcome expectancies. Third, it is assumed that the participants responded truthfully and accurately to all questions. Finally, it is assumed that the data from the self-report instruments, STEBI-Form A and the Demographic Survey have minimal research error.

Delimitations

There are three delimitations to this study:

1. The first delimitation is the lack of random assignment of the participants. The teachers volunteered for this inquiry-based professional development program based on their need to become highly qualified in science, or because their principal suggested that they attend.

2. The second delimitation for this study is the selection process of the participants. The only criterion was that participants came from school districts in a specified tri-county area in close proximity to the university site where the inquiry-based professional development program took place. Since the program met at specific times and venues over two summers and one school year, the participant selection was limited to those who could attend all sessions over the time period of 15 months.

3. Finally, the third delimitation is the varied individual backgrounds of the participating teachers. They were a heterogeneous group of teachers that varied in age, gender, years of science teaching, and professional position (science teacher, special education teacher). Consequently, the participants held different initial self-efficacies and outcome expectancies at the beginning of the professional development program.

Definitions and Operational Terms

The meanings of terms commonly used in education can be interpreted in different ways. To ensure clarity for the reader the following definitions are provided below:

Beliefs, according to Bandura (1997), are the best indicators of the decisions people make throughout their lives. Hofer (2006) defines beliefs as being "multidimensional," developing over time. She adds that individuals move through a sequence of development in their growth of knowledge and knowing and therefore belief is deeply rooted in cognitive development. It is through educational experiences that these beliefs can be developed or changed. In this study, the researcher examined any differences in beliefs that took place with the teachers before and after participation in an inquiry-based professional development program regarding their own self-efficacies and outcome expectancies.

Constructivism is a philosophy of education which implies that humans can only clearly understand what they themselves have formed. Constructivism is an active process in which learners build new ideas or concepts based upon their current and past knowledge. Constructivism in science involves encouraging learner inquiry,

acknowledging the critical role of experience in learning and nurturing learners' natural curiosity. In addition, constructivism emphasizes performance and understanding when assessing learning. For this study, constructivism was the philosophy underlying the inquiry-based professional development program featured in this study.

Demographics Survey is a self-report questionnaire used to provide descriptive information regarding the participants (see Appendix B).

Highly Qualified Teacher (HQT) of science is one who meets the required hours of science content knowledge to satisfy the federal definition of a highly qualified teacher of science (see Appendix C).

Inquiry is a term defined by the National Science Education Standards (NRC, 1996) and refers to the following:

> diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p. 23)

Constructivism and inquiry are the bases for all sessions in this professional development program.

Inquiry-based Professional Development Program is an intensive 120 hours of inquiry-based instruction provided over a 15-month time frame in which participants experience 2 weeks of summer activities with inquiry-based lessons and strategies. Program coordinators intended that participants implement similar lessons with their own students throughout the included school year. Participants received further instruction and interaction with professional development providers during the second summer.

Outcome Expectancy is the behavior enacted when people expect specific behavior to result in desirable outcomes. For this study, outcome expectancies refer to the teachers' belief that student learning of science can be influenced by effective teaching.

Participants are those who completed the 120 hours of inquiry-based professional development program over the 15-month time frame.

Personal Science Teaching Efficacy Scale (PSTE) is one subscale of the STEBI that measures the belief that one's teaching ability is related to positive changes in students' behaviors and achievement levels.

Professional Position refers to the teaching title, which is self-reported by each participant on the demographic survey, as intervention specialist, classroom teacher, science resource teacher or district administrator.

Science Education Background refers to the number of college science courses completed that each participant self-reported on the demographics survey.

Self-efficacy refers to one's beliefs about their capabilities to produce effects (Bandura, 1994). It is concerned not with the skills one has but with judgments of what one can do with the skills one possesses (Bandura, 1986).

Science Teacher Efficacy Belief Instrument (STEBI Form A) is a quantitative instrument based upon Bandura's social learning theory that beliefs are part of the foundation upon which behaviors are based. The STEBI is composed of two subscales that specifically measure and come from this theory; self-efficacy and outcome expectancy. Self-efficacy is measured by the subscale Personal Science Teaching

Efficacy Scale (PSTE). The outcome expectancy is measured on the subscale, Science

Teaching Outcome Expectancy Scale (STOE; Enochs & Riggs, 1990) (see Appendix D).

Science Teaching Outcome Expectancy (STOE) is one subscale on the STEBI

that measures the belief that any teacher, in spite of all factors, can affect student

learning.

Teacher Qualification Status refers to one who meets the federal definition of a

highly qualified teacher (see Appendix C).

Years of Experience is defined as the number of years each participant has been

teaching science.

CHAPTER II

LITERATURE REVIEW

General Background Information

The following is a review of the literature related to the variables of interest to this study. The chapter is divided into five sections. The first section covers the historical background of the relevant epistemology and the numerous definitions researchers have established for its meaning in relation to education. The second and third sections focus on specific details of epistemology, the notion of beliefs and self-efficacy and their relationship to the overall term epistemology. The fourth section discusses previous studies which have used the Science Teaching Efficacy Belief Instrument (STEBI) as it measures self-efficacies and outcome expectancies. The last section discusses professional development of science teachers, including Highly Qualified Teacher status in science.

Epistemology

Personal epistemology is an umbrella term that encompasses findings from educational psychology. It is referred to under a variety of names such as epistemological or epistemic beliefs, reflective judgment (King & Kitchener, 1994, 2004), ways of knowing, and epistemological reflection. In the last decade educational

psychologists began to take a major role in refining, testing, and expanding these definitions (Hofer, 2005). Hofer and Pintrich's work focuses on the clarity of defining personal epistemology, the nature of individuals' conceptions of knowledge and knowing how these conceptions are related to learning, teaching and education (Hofer & Pintrich, 1997). They define personal epistemology as an individual's cognition about the nature of knowledge and knowing, organized as theories, progressing in reasonably predictable directions, activated in context, and operating both cognitively and metacognitively (Hofer, 2001, 2004a; Hofer & Pintrich, 1997). For most educational psychologists interested in personal epistemology, it is the connection to motivation, cognition, and learning that initially captivated their attention and continues to drive interest (Hofer, 2005). Hofer and Pintrich suggest connections between personal epistemology and conceptual change, and they advocate further research on the relation between epistemology and motivation, learning strategies, pedagogical approaches, and classroom context (2005).

Hofer (2006) suggests that personal epistemologies develop over a person's life span. Specifically, Hofer (2001) states, "Equally important, epistemological thinking is related not only to school learning, but is a critical component of lifelong learning, in and out of school" (p. 354). Hofer (2006) adds that personal epistemologies are beliefs that individuals hold about knowledge and knowing and are related to learning and achievement in complex ways and that these beliefs are differentiated by disciplines (ex. science) and judgment domains (ex. personal taste). She also explains that epistemological development might be viewed as signs of moving in a horizontal direction that Piaget described in terms of cognition development (Hofer, 2006). Hofer

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(2005) states, "If we are clear on our assumptions and models, then progress can still be made on understanding how and why personal epistemologies are related to cognition, motivation, and learning in academic contexts" (p. 99).

Lising and Elby (2004) define personal epistemology as one's own knowledge and learning with more emphasis on learning. They explain that fostering productive attitudes and epistemologies is an important instructional outcome that could positively serve students. Hofer (2001) adds that personal epistemology is related not only to school learning, but is also a critical component of life-long learning. Hofer (2001) further explains that personal epistemologies help us understand how individuals resolve competing knowledge claims, evaluate new information, and make fundamental decisions that affect their lives (Hofer, 2001). Additional research on personal epistemologies addresses the thinking and beliefs about knowledge and knowing, beliefs about the definition of knowledge, how knowledge is constructed and evaluated, and how knowing occurs and where knowledge resides (Hofer, 2001). Since epistemology is developmental and development is one of the aims of education, epistemology, therefore, is part of the goal of education.

Hofer (2001) offers three general views that demonstrate the existing connection among epistemology, learning, and instruction:

1. Epistemology is developmental. Development is the aim of education and thus part of the goal of education to foster epistemological development.

2. Epistemology exists in the forms of beliefs. Learning is influenced by epistemological beliefs that individuals hold (outcome leads to academic performance).

3. Epistemology is either theory-like or exists as more fine-grained epistemological resources, which are engaged in ways that are context-dependent (outcome is learning and knowledge construction).

Hofer (2001) adds that educational experiences play a role in fostering development or belief change. It is the beliefs of teachers that may also influence this process. Given that beliefs are an integral component of epistemology, studying beliefs as they develop over time in relation to education and experience will be one area of focus in this research.

<p style="text-align:center">Beliefs and Practices</p>

Initially, when researchers studied epistemology, they focused on individuals' beliefs about the nature of knowledge, for example, beliefs about certainty and the source of knowledge (Perry, 1968). In 1990, the focus of epistemology studies expanded to include beliefs about learning, namely the speed and ability to learn (Schommer, 1990). All of these aspects of epistemology were then labeled with the umbrella term, "epistemological belief system" (Schommer, 1990). Since then, a wide variety of research has been conducted to link personal epistemology to various aspects of learning including beliefs and practices (Bendixen, Dunkle & Shraw, 1994; Hofer, 2004a; Kardash & Scholes, 1996; Schommer, Crouse & Rhodes, 1992; Schommer & Walker, 1997).

In 1990, Schommer proposed that personal epistemology be reconceptualized as an epistemological belief system that includes beliefs about the nature of knowledge and the nature of learning. She explains that these beliefs encompass:

1. Structure of knowledge – ranging from bits and pieces to integrated concepts,

2. Stability of knowledge – ranging from unchanging to continually changing,

3. Source of knowledge – ranging from handed down by authority to derive from evidence,

4. Speed of learning – ranging from quick all or none to gradual and

5. Ability to learn – ranging from fixed at birth to improvable over time and experience.

Schommer (1990) further states that each belief or specific combination of beliefs may play a unique role in learning practices and problem solving.

Duell and Schommer-Aikens (2001) note that epistemological beliefs play an important role in education. They state that personal epistemology would be better portrayed as a system of independent beliefs; therefore being multidimensional. This important distinction helps to explain the complex idea that beliefs and practices are components of personal epistemology.

Teachers' Beliefs

The study of personal epistemology is important because it is likely that it plays multiple roles in students' beliefs and learning practices (Schommer-Aikens & Easter, 2006). Schommer-Aikens and Easter add that it is highly likely that personal epistemology plays a role in how teachers make decisions about curriculum, instruction, and evaluation (Schommer-Aiken & Easter, 2006).

In *Strategies for Enhancing Teachers' Beliefs in their Effectiveness: Research on a School Improvement Hypothesis*, Ross (1995) argues that teacher efficacy affects teachers. Teachers who anticipate success set more challenging goals for themselves, and their students accept responsibility for the outcomes of instruction and persist through obstacles. The findings of this research suggest that student achievement can be enhanced by strengthening teacher efficacy. Ross also states that while our understandings of the origins and outcomes of teacher beliefs about their effectiveness have grown substantially, the use of these findings in teacher development programs has not (Ross, 1996).

Oliver and Koballa (1992) indicate that beliefs are oftentimes equated with knowledge, attitudes, and personal convictions, or reflect a person's acceptance or rejection of a proposition (Oliver & Koballa, 1992). Pintrich's (2002) contribution to belief research suggests that the conceptual change of Dewey (1910) was one of the first to state that beliefs of teachers may prove an important basis for their professional practice. Hofer (2006) defines beliefs as being multidimensional, developing over time in relation to education and experience and moving from the general to specific during development. Richardson (1996) states that beliefs play a central role in organizing knowledge and defining behavior. Hofer (2001) suggests that individuals move through a patterned sequence of development in their beliefs about knowledge and knowing, which has roots in cognitive development. As individuals move through a sequence in their ideas about knowledge and knowing, their ability to make meaning evolves (Hofer, 2001). Hofer (2001) also adds that educational experiences play a role in fostering development or belief change. Research suggests that beliefs about knowledge are

domain specific, ex. science (Bell & Linn, 2002; Hammer, 1994; Hammer & Elby, 2002; Hogan, 1999, 2000).

Hofer and Pintrich (1999) state there is congruence between instructor's espoused beliefs and their actual practices. Hofer (2001) adds that it is the beliefs of teachers that influence relationships between methods and personal epistemologies. Bryan and Abell's (1999) research suggests that teachers make instructional decisions based on complex systems of knowledge and beliefs.

Teachers hold beliefs beyond matters of their profession, and although these global beliefs influence teacher practice, they can be distinguished from the beliefs teachers hold that are more specific to the educational process. Educational beliefs include beliefs about students and the learning process, about teachers and teaching, about nature of knowledge, about the roles of schools in society, and about the curriculum. All teachers hold beliefs, however defined and labeled about their work, the subject matter they teach, and their roles and responsibilities (Levitt, 2002).

Teachers' beliefs about the importance of the content taught, their beliefs regarding appropriate instructional strategies, and their sense of self-efficacy have all been found to influence instruction (Hargreaves & Fullan, 1992; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Schulman, 1991). Nespor (1987) adds in his study, *The Role of Beliefs in the Practice of Teaching* that the values placed on course content and beliefs often influence how teachers taught the content. Olafson and Schraw (2006), in their beliefs research, which includes teachers, suggest that teachers' epistemic beliefs are related more to process than to content. Pajares (1992) adds that teachers' beliefs may be closely related to understanding student epistemology and explains that clusters of beliefs

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around a particular situation form attitudes, and attitudes become action agendas that guide decisions and behaviors. In other words, people act upon what they believe. Similarly, according to Bandura (1997a), beliefs are thought to be the best indicators of the decisions people make throughout their lives. Pintrich (2001) suggests that teachers are either facilitated or constrained by epistemological beliefs. As the research base grows in this field, the need to speak directly to practitioners about the utility and importance of attending to beliefs about knowledge and knowing and about their influence on strategy use, comprehension, conceptual change and cognitive processes becomes vital (Pintrich, 2002). He also adds that at the disciplinary level, teachers need increased attentiveness to teaching the epistemology of their fields, discussing how knowledge develops and how it is validated (Pintrich, 2002).

Pajares' research in the area of teacher beliefs suggests that teachers' beliefs may be a stronger predictor of behavior than knowledge as teachers implement designed programs. He further states that the beliefs that teachers hold about teaching and learning, including beliefs about their students, have a significant influence on the teachers' behaviors (Pajares, 1992). The construct of beliefs is "less messy", far cleaner when precise meanings are consistently understood and adhered to, and when specific belief constructs are properly assessed and investigated. Beliefs are the single most important construct in educational research (Pajares, 1992).

Pajares (1992) asserts that beliefs are the best indicators of the decisions that individuals make throughout their lives, for example, the choices they make for teaching strategies in the classroom. Teachers' beliefs about the importance of the content taught, their beliefs regarding appropriate instructional strategies, and their sense of self-efficacy

have all been found to influence instruction (Hargreaves & Fullan, 1992; Loucks-Horsley et al., 1998; Schulman, 1991).

In Nespor's (1987) study, *The Role of Beliefs in the Practice of Teaching*, which was an intensive, 2-year program of research on the structures and functions of teachers' belief systems, eight teachers in three school districts were videotaped over the course of a semester and were interviewed for a total of approximately 20 hours. One of his findings was that the values placed on course content and beliefs often influence how teachers taught the content (Nespor, 1987).

Beliefs and Science Teaching

There is a critical relationship between the beliefs of teachers regarding implementation of science education reform efforts and instructional decisions (Lumpe, Haney, & Czerniak, 1998, 2000). Both prospective and inservice teachers develop their beliefs about teaching from years spent in the classroom as both students and teachers. Many teachers' beliefs of teaching are not necessarily consistent with the literature about best practice in teaching; yet teachers' beliefs appear to be stable and resistant to change (Lumpe et al., 2000).

Science teachers possess beliefs regarding professional practice. Understanding that beliefs may effect actions, teachers' beliefs play a critical role in their own professional practice. Studies reviewed suggest that teacher beliefs are a critical ingredient in the factors that determine what happens in the classroom. Tobin, Tippins, and Gallard (1994) explained from their research that teachers' beliefs are pervasive in the classroom and influence the nature of teachers' roles, planning and decision-making

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processes, and ultimately the curriculum. Loucks-Horsley et al. (1998) developed a professional development model indicating that a teacher's context and his/her beliefs directly affect goals and plans and that these goals and plans ultimately lead to action.

Haney and Lumpe (1995) conducted research to examine three questions:

1) What are science teachers' beliefs regarding the necessity of science reform?

2) What are teachers' perceptions regarding their implementation of reform strands in their classrooms?

3) How do teachers' beliefs relate to their perceived implementation of science reform strands in their classroom?

Their study consisted of 400, K-12 teachers who were randomly selected from schools in Ohio. The instrument used in this study was the Innovations in Science Education Survey Instrument (Haney & Lumpe, 1995) which measures teachers' beliefs about reform and the degree of implementation of these reforms. The researchers found over 80% of teachers believe most of the reform strands were "necessary" or "very necessary" to be an effective science teacher. Consequently, the researchers proposed a framework for science teacher professional development indicating that the identification of teachers' beliefs about science teaching is critical to the reform process (Haney & Lumpe, 1995). In a subsequent study, Lumpe et al. (2000) developed an assessment designed to measure teachers' beliefs about current science education reform themes. They surveyed 130 teachers of science using the Context Beliefs about Teaching Science (CBATS) instrument, which they developed. Results indicate that teachers' beliefs are the strongest impetus for change (Lumpe et al., 2000).

Brown and Melear (2006) believe teachers' beliefs and practices will change as a result of experiences with authentic inquiry-based science methods. It is their hope that teachers' beliefs of the scientific processes and their skills in experimentation procedures help teachers incorporate more inquiry-based methods that focus on students' thinking in their classrooms. They also state when teachers display these values of everyday science, students will assimilate similar attitudes into their dispositions; hence, a teacher with a belief construct of inquiry-based science will be more likely to practice inquiry with his/her students by modeling authentic science skills in a student-centered environment (Brown & Melear, 2006). They also state that simply holding beliefs about the benefits of inquiry-based practices is not always sufficient to implant them into the classroom (Brown & Melear, 2006).

In addition, Guskey (1985) and Bolster (1983) report that practice of new ideas often precedes changes in beliefs regarding those new ideas. Peterson, Fennema, Carpenter and Loef (1989) refer to these practice beliefs as pedagogical beliefs, and they maintain that along with content knowledge, these beliefs about practices provide a strong link to classroom action.

The teachers' beliefs about science and their roles in implementing inquiry-based science lessons influence decisions about their teaching of science (Levitt, 2002). In order to measure teachers' beliefs regarding their science teaching and the learning of science by their students, teacher self-efficacies and outcome expectancies of student learning become important variables to study.

Self-efficacy and Outcome Expectancy

Self-efficacy is a construct within Bandura's (1997b) social cognitive theory of behavior and motivation. Self-efficacy is a component of one's belief system as well as one's self-confidence and self-esteem. Bandura suggested that people develop a generalized expectancy about action-outcome contingencies based upon life experiences. Additionally, people develop specific beliefs concerning their own coping abilities. Bandura called this phenomena self-efficacy. According to Bandura (1977b), behavior is based upon two conditions; people's expectations regarding certain behaviors to produce desirable outcomes (outcome expectancy), and people's beliefs in their own ability to perform behaviors (self-efficacy). Bandura (1977b) suggested that people with both high outcome expectancy and self-efficacy act in an assured, confident manner. Low expectancy paired with high self-efficacy might cause the individual to believe in themselves but may eventually lead to frustration. Persons with both low outcome expectancy and self-efficacy would tend to give up more readily if the desired outcomes were not met.

Bandura (1994) explained that people's beliefs about their efficacy develop from four main sources of influence:

1. Mastery experiences – Bandura explains the most effective way of creating a strong sense of efficacy is through successes. Failures undermine self-efficacy, especially if failures occur before a sense of efficacy is firmly established.

2. Vicarious experiences – creating and strengthening self-efficacy can be accomplished by providing models. Seeing people similar to oneself succeed raises observers' beliefs that they can also posses the same capabilities to succeed.

3. Social persuasion – this strengthens people's beliefs that they possess the characteristics to succeed and will demonstrate greater effort and sustain success longer.

4. Reduction of stress – by modifying people's stress reactions self-efficacy can be increased if positive mood enhancement is perceived.

When Bandura's (1977a) theory of self-efficacy is applied to teachers and their learning in a professional development program, Gibson and Dembo (1984) state the following:

> teachers who believe student learning can be influenced by effective teaching (outcome expectancy beliefs) and who also have confidence in their own teaching abilities (self-efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning. (p. 570)

These two factors, self-efficacy and outcome expectancy, are independent of one another. A teacher may believe that he/she has the ability to positively impact his/her students' learning (high PSTE) and yet feels that teachers in general, have little impact on positively influencing students due to the numerous outside factors, which also contribute to the success or failure of the students (Enochs & Riggs, 1990).

Measuring Self-efficacy and Outcome Expectancy

Several instruments have been developed to measure various constructs regarding self-efficacy beliefs, and the teaching and learning of science. The Teacher Efficacy Scale (TES) was developed by Gibson and Dembo (1984) to measure preservice teachers' self-efficacy beliefs by addressing the areas of their effort, skills, training, and experience. The TES was criticized for not clearly capturing the dimension of personal

efficacy as described by Bandura's definition of the self-efficacy construct (Gibson & Dembo, 1984).

Schommer's, Epistemological Beliefs Questionnaire, measured preservice teachers' beliefs about knowing and provided information about changes in their epistemological beliefs. The 5-point, 63-item Likert-type questions were designed to measure students' beliefs about Simple Knowledge, Certain Knowledge, Innate Ability, Quick Learning, and Omniscient Authority (Schommer, 1990).

The Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) developed by Ritter, Boone, and Rubba (2001) was designed to assess preservice teachers' self-efficacy and outcome expectancy beliefs with regard to science teaching and learning in an equitable manner when working with diverse learners. The scale specifically focuses on self-efficacy beliefs in relationship to teaching students from various socioeconomic backgrounds, gender differences, cultural, and children who speak English as a second language (Ritter, Boone, & Rubba, 2001).

Lumpe et al. developed the Context Beliefs about Teaching Science instrument (CBATS) (2000) to be used to assess science teachers' context beliefs about current science education reform themes. This instrument was designed for inservice K-12 teachers. The authors suggested it could be used to determine factors which predict particular personal agency belief patterns, assessing teachers' perceptions of strengths of school science programs, and also used in planning professional development experiences for science teachers. They also suggested that this instrument be used as a complement with other instruments that measure self-efficacy (Lumpe et al., 2000).

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While the above instruments have examined self-efficacy beliefs, Enochs and Riggs (1990) have taken Bandura's theory of self-efficacy and applied it when studying science teacher behavior. They developed the Science Teaching Efficacy Belief Instrument (STEBI) specifically to measure changes that take place in teachers' self-efficacies and outcome expectancies of student learning.

The theoretical basis for developing an instrument to measure science teachers' self-efficacies and outcome expectancies was derived from Bandura's (1977a) theory of beliefs. Riggs recognized a need for an instrument that would specifically measure the beliefs of elementary science teachers regarding science teaching and learning. She therefore, constructed, validated and determined the reliability of the Science Teaching Efficacy Belief Instrument (Riggs, 1988).

The STEBI closely aligns with Bandura's construct, is content specific, and investigates two distinctive subscales; Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Because of the established reliability and validity of the STEBI, it has been used extensively in numerous research studies. An extensive search of the literature revealed 15 studies that utilized the STEBI as an instrument. Of the 15 studies found, eight were used for inservice teachers in professional development programs, and the remaining studies were conducted with preservice teachers.

STEBI Findings

Many researchers have conducted studies using the STEBI-B (teacher candidate version) (Bleicher, 2006; Cakiroglu, Cakiroglu & Boone, 2005; Cantrell, Young &

Moore, 2003; Watters & Ginns, 1995; Wingfield, Freeman & Ramsey, 2000). Wingfield

et al. (2000) conducted a study to determine if gains in self-efficacy obtained from a

preservice program at a university would be maintained throughout the first year of

teaching in their own classrooms. The sample for this study consisted of the entire

population of undergraduate elementary preservice teachers at a university. The 131

participants completed STEBI-Form B pretests and posttests. Statistically significant

mean score gains for both subscales were noted. The Personal Science Teaching Efficacy

(PSTE) mean score gains yielded a *t* value of 10.67 which was statistically significant at

p <.001. The Science Teaching Outcome Expectancy (STOE) mean score gains yielded a

t value of 8.56 which was statistically significant at *p* <.001. One year later the STEBI-

Form B was mailed to all participants. In total, only 31 (22%) completed the STEBI

surveys. Researchers found the PSTE mean which had increased from 46.77 to 53.78,

remained at 52.26 after one year. The STOE mean which had increased from 36.05 to

39.32 had remained at 38.71 after one year. Results of this study indicated that the

experiences in the preservice program had produced a significant positive impact on the

preservice teachers' self-efficacy to last through their first year of teaching (Wingfield et

al., 2000).

Cakiroglu et al. (2005) implemented the STEBI-Form B in their study comparing

preservice elementary teachers' efficacy in a Turkish university, and in a major American

university located in the Midwest. The Turkish sample consisted of 100 preservice

elementary teachers and in the American sample there were 79 preservice elementary

teachers. Mean gain scores were reported for the Turkish students as PSTE = 4.25 and

STOE = 4.37. The American students mean gain scores were PSTE = 4.65 and STOE =

4.19. The researchers concluded that results from this study indicate that there were

differences in personal efficacy beliefs of the American and Turkish samples of

preservice teachers. The largest difference was the American preservice teachers having

a stronger personal science teaching efficacy beliefs than Turkish preservice elementary

teachers.

Results from Bleicher (2006) indicate that with guidance and intensive

interactions between professors and preservice teachers in class discussions and small

group hands-on activities, personal science teaching self-efficacies increases. Professors

who model effective teaching strategies and provide learning opportunities that integrate

content knowledge with hands-on learning experiences increase preservice teachers' self-

efficacies about their abilities to teach science in their future careers. Outcome

expectancies also increase when individual college students successfully teach science

lessons to grade school students (Watters & Ginns, 1995). This information may be

useful in planning for coursework that would enhance teaching self-efficacy throughout

the teacher preservice curriculum (Cantrell et al., 2003). Since this study focused on

inservice teachers in the professional development training, the remaining sections focus

on research findings using the STEBI-Form A (form for practicing teachers).

Numerous research studies focused on inservice programs for practicing teachers

used the STEBI-Form A. Tschannen-Moran, Woolfolk-Hoy, and Hoy (1998) conducted

a year long professional development program in which they used the STEBI-Form A to

measure the teachers' self-efficacies and outcome expectancies. They concluded that

teachers with high PSTE spent more time teaching science, demonstrated a high level of

personal relevance in science, and enjoyed performing science activities outside the

classroom. On the contrary, they found teachers with low PSTE spent less time teaching science, used a text-book approach, received weak ratings by outside observers, and made fewer positive changes in their beliefs about how children learn science.

In a survey of 262 teachers, grades K – 12, Lumpe et al. (2000) determined that there was a positive correlation between environmental characteristics and outcome expectancies. The purpose of their study was to develop and apply an assessment strategy designed to gauge teachers' beliefs about the potential influence of specific environmental factors on their science teaching behaviors. These environmental factors included support from administrators, availability of a common planning time, reduced class size, resources, and additional funding. Their results reported a mean score of 47.56 on the PSTE subscale and a 41.29 on the STOE subscale. Total score possible for the PSTE subscale is a 65 and for the STOE subscale is 60.

Another study (Riggs, 1995) reported that teachers who began with low PSTE and STOE made gains in self-efficacies but remained constant in outcome expectancy scores (Riggs, 1995). These findings were supported by the work of Roberts, Henson, Tharp and Moreno (2001) who surveyed 330 elementary teachers and found that professional development activities had the greatest impact on the efficacy of teachers who began their program with the lowest self-efficacies. The purpose of their study was to determine the optimum length of teacher inservice programs when increasing teacher efficacy. Their study spanned an 8-year period, from 1992-1999. The programs varied in length from 2 to 6 weeks in duration. The length of inservice varied but the purpose and content stayed the same. Only STEBI-Form A scores and length of intervention were used in the analysis. Only the PSTE subscale was reported in the analysis of this

study. Researchers reported only four of the inclusive years studied (one 2 week program, one 3 week program, one 4 week program, and one 6 week program). Their results showed an increase mean gain score of 5.04 (2 week program), 6.24 (3 week program), 7.47 (4 week program), and 6.47 (6 week program) in the PSTE score for each year. The researchers concluded there was little statistical difference in mean scores between the programs with the greatest increase in PSTE during the 4-week program. (Roberts et al., 2001).

One study examined the relationship between teachers' science education backgrounds with their self-efficacies. Ramey-Gassert et al. (1996) found an influential change in PSTE score due to high quality science courses, workshops and support from colleagues. This study did not mention the number of science courses that the participants completed. They also reported there was a minimal change in STOE scores (Ramey-Gassert et al., 1996).

In a 32-week professional development program, Posnanski's (2002) objective in the study was to measure any improvements in self-efficacy beliefs, develop personal philosophy of science teaching, and promote the use of new teaching strategies. Thirty-one elementary teachers, grades K – 6, were involved meeting once a week for 3 to 4 hours, 32 weeks during the school year. The participants ranged from novice teachers to those having 17 years of teaching experience. Teams of teachers (2 to 4 members) from each building represented participated in the program. The STEBI-Form A was used for program evaluation, administered as a pre-, post- project evaluation. Posnanski found the 43 elementary inservice teachers' PSTE scores were statistically significantly enhanced from a mean score of 44.71 on the pretest to 51.48 on the posttest. Their STOE scores

were not statistically significantly affected; the mean score on the pretest was 41.74 and the posttest was a 42.97. Posnanski concluded that a professional development program based on a constructivist framework can positively influence the science teaching self-efficacy of the participants (Posnanski, 2002).

Crowther and Cannon (2000) conducted a professional development 2-week workshop for 78 practicing chemistry teachers. The STEBI-Form A was administered three times, prior to the inservice workshop, post-workshop and a third time, 5 months after the conclusion of the workshop. The researchers concluded there were no statistically significant changes in PSTE scores; however, there were significant increases in the outcome expectancies between the post-workshop and the final assessment. The researchers speculated that this increase may have occurred due to teacher networking and collaborating in their home schools as opposed to the professional development workshop itself (Crowther & Cannon, 2000).

Eshach (2003) conducted two 4-day workshops for K – 2 teachers, where the goal was to incorporate "inquiry-event" activities for teachers in order to raise their self-efficacies. The STEBI was administered on the first and last day of the workshop. The 30 participants increased both their PSTE mean gained score from 3.45 to 3.94, and the STOE mean gained score from 3.95 to 4.45. Eshach concluded that by introducing teachers to "inquiry-event" activities, their science teaching self-efficacy will rise (Eshach, 2003).

In 1995, Haney and Lumpe (1995) surveyed 168 randomly selected K – 12 teachers from school districts in Ohio. Twice the participants were sent by mail the STEBI and Biological Sciences Curriculum Study (BSCS) Innovations in Science

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Education Survey Instrument. Descriptive data and regression analysis techniques were used to address the research questions regarding improving science reform movements. The dependent variables of their study were: teachers' beliefs about the necessity of reform and degree of implementation of reform. The independent variables were self-efficacy, outcome expectancy, number of years teaching, grade level taught, and degree held. Researchers reported that teachers' beliefs about the necessity of reforms to be an effective teacher accounted for 33% of the variance in degree of reform implementation in the teachers' classrooms. None of the other variables were strong predictors on their reform implementation in the classroom. Findings from this study support the notion that reform movements in science education need to be more cognizant of teachers' beliefs (Czerniak & Lumpe, 1995).

Stewart (2000) conducted an in-depth study of the training of elementary teachers in reform methods. She used a variety of qualitative and quantitative assessments, including the STEBI-Form A. Thirty-two elementary teachers from urban schools and Native American reservations participated in a 4-week summer workshop and follow-up sessions throughout the following school year. The STEBI was administered at the beginning of the program, immediately following the summer session and 11 months later at a spring sharing session. The participants mean score on the PSTE increased from 47.66 (pretest), to 52.28 (posttest), and further to 55.81(delayed posttest). The STOE mean scores also increased from 41.84 (pretest), to 43.83 (posttest), to 46.11 (delayed posttest). Based on these results, Stewart indicated that these teachers believe that the inquiry methods presented during the professional development workshop will

increase students' abilities to learn science over their teachers' current methodologies (Stewart, 2000).

Marion (1998) examined the relationship between science teaching efficacy scores and gains in physics content knowledge. Sixty-one elementary teachers participated in 10, six-hour consecutive workshop days in the summer. The STEBI was administered on the first day (N = 57) and the last day of the summer session (N = 53). A third STEBI was administered (N = 36) the following November at a follow-up session where the teachers met to discuss what had transpired in their classrooms. Mean gained scores were reported for the PSTE subscale as 7.02 (pretest), 11.22 (posttest), and 3.78 (follow-up posttest). STOE mean gain scores results were 1.40 (pretest), 1.14 (posttest), and -0.22 (follow-up posttest). Marion's results indicated that while subject knowledge is positively related to a teacher's sense of efficacy, there are many other variables influencing self-efficacy and outcome expectancy. For example, Marion explained teachers will often enter an inservice program with a high level of self-efficacy and as issues of new content are presented they may begin to realize that their knowledge is not complete as they thought. The teachers may then feel a loss of their sense of competence and self-efficacy as they attempt to adopt new skills and behaviors. In addition, Marion also explained the fact that the posttest was given immediately following the workshop. Had the posttest been given after a longer period of time where the teachers would have been given more time to practice the new behavior and content, the data may have verified the predicted positive relationship between knowledge gains and self-efficacy gains (Marion, 1998).

Khourey-Bowers (1995) examined an inservice training project founded in conceptual change theory that would result in the enhancement of effective teaching. Forty middle school teachers completed the STEBI-Form A to measure the construct of self-efficacy. A 3-week summer training program with the purpose of increasing science content knowledge was held with an additional follow-up session 6 months later. The STEBI-Form A was administered, pretest, posttest (at the end of the summer session), and a follow-up (6 months later). The mean PSTE scores were: 47.25 (pretest), 50.44 (posttest), and 53.13 (follow-up). The STOE mean scores were: 41.34 (pretest), 40.78 (posttest), and 40.41 (follow-up). Khoury-Bowers concluded that although there was a gain in teachers' self-efficacy, there was not an overall gain in outcome expectancy. She suggested the implications are that the participants have not changed their assessment of student characteristics but believe that they personally can accomplish more than before in the same environmental situation. She further explained this is a very beneficial effect for those teaching in potentially difficult situations, such as urban school districts (Khoury-Bowers, 1995).

Inquiry

The National Research Council (NRC, 1996) calls for the focus of science education reform to include inquiry-based instruction. Before children ever enter a school building, in fact from birth, they are naturally curious about all of their surroundings. As infants, children are extremely interested about everything around them. They want to see, feel, and even touch everything in order to learn about their surroundings. They innately employ trial and error techniques to explore the world around them (NRC,

2000). The NRC (2000) states that it is this natural curiosity that educators need to exploit so that children do not lose this curiosity when they attend school.

Early humans who never had formal schooling explored the world around them by using similar trial and error techniques. When they would be faced with an unknown situation, such as looking for food or shelter or perhaps trying to stay out of danger, they would try to determine what was happening and predict what would happen next in order to solve a problem. They also observed, gathered, assembled, and synthesized information in order to gather food, escape danger, or help in some way to answer a problem (NRC, 2000). Both of these groups of people exhibit a state of mind for inquiry which is that of inquisitiveness and curiosity.

In 1996 the NRC released the National Science Education Standards (NSES; NRC, 1996) which stated that the United States science education's prominent feature had to focus on inquiry. They defined inquiry as a multifaceted activity that includes:

1.The abilities students should develop to be able to design and conduct scientific investigations and the understandings they should gain about the nature of scientific inquiry.

2. It refers to the teaching and learning strategies that enable scientific concepts to be mastered through investigations.

The Standards include drawing connections between learning science, learning to do science, and learning about science.

Inquiry in the Classroom

Inquiry in the classroom can take many forms ranging from a highly structured setting where the investigations are structured by the teacher so that students proceed toward a known outcome, such as a particular law in physics. Inquiry investigations can also involve open-ended explorations in which the student or teacher initiates a question about unexplained phenomena, and they try to discover some possible answers (NRC, 2000). Educational goals and diversity of the students may determine which form of inquiry should be employed in a classroom. Inquiry in the classroom begins by curiosity and asking questions based on current knowledge. Students then propose preliminary explanations or hypotheses based on observed information. From this information they plan and conduct a simple experiment, gathering information from observations. Based on the evidence, they then give an explanation, consider other possible explanations, and finally communicate their findings to the rest of the class. There may be a need for further testing based on new information that arises through this process (e.g., new questions).

Inquiry in the National Science Education Standards

In 1996 the NRC released the NSES, which became the driving force behind improvements in science education. Its primary focus was on inquiry. The NRC writes that the Standards are committed to including inquiry as both science content and as a way to learn science. The NRC treats inquiry as both a learning goal and as a teaching method.

The National Science Education Standards define inquiry as a multifaceted activity that involves making observations, posing questions, examining books and other sources of information to see what is already known. Planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyzing and interpreting data; proposing answers, explanations and predictions; and communicating the results are all important components of inquiry in the classroom. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (NRC, 1996).

The NSES defines inquiry as a vital teaching strategy that teachers should employ on a continuous basis. It describes five essential features that define inquiry teaching and learning across all grade levels:

1. Learners are engaged by scientifically-oriented questions. Scientists recognize that there are two kinds of questions, "why" questions which probe origin and existence and "how" questions which probe mechanism and causal/function. These questions generate a need to know and stimulate additional questions. Questions may be initiated by the learner, the teacher, instructional materials, the internet, or some other source or a combination. The teacher guides the identification of the question and helps students focus their questions to experience interesting and productive investigations (NRC, 2000).

2. Learners give priority to evidence which allows them to develop and evaluate explanations that address scientifically-oriented questions.

3. Learners formulate explanations from evidence to address scientifically-oriented questions.

4. Learners evaluate their explanations in light of alternative explanations, particularly reflections of scientific knowledge.

5. Learners communicate and justify their proposed explanations.

The teaching strategies and instructional materials that make full use of inquiry must include all five of the above essential features. If all five essential features are present, the inquiry is said to be "full". The amount of inquiry-based teaching can vary in the amount of detailed guidance that the teacher provides, from "open" inquiry, which is best for developing cognitive development and scientific reasoning to "guided" inquiry, which can best focus learning on the development of a particular science concept.

Tafoya, Sunal and Knecht (1980) specifically defined and outlined topography, or a continuum for defining inquiry based on the instrument Assessment of Inquiry Potential (AIP), developed by Knecht (1974), which is an analytic tool that classifies the degree to which students participate in the processes of knowledge acquisition. Tafoya et al. define four different degrees of inquiry activities by students:

1. Confirmation activities – a concept or principle is presented and the students perform some experiment to confirm the results. The students know what to expect and the details of the procedure are outlined for them to follow.

2. Structured activities – students are presented with a problem but do not know the outcome when they begin. Procedures are outlined by the teacher as well as materials and activities that are structured in such a way to enable the students to discover the information, collect data, and generalize results.

3. Guided inquiry – only the problem is given to the students for investigation. The students make decisions on materials, procedures, and data collection methods to follow in order to generalize results.

4. Open inquiry – the students formulate the problem, the procedure for solving the problem, interpret the results, and arrive at a conclusion (Tafoya et al., 1980). Teachers as students need to experience all four degrees of inquiry. The key elements for the intended learning outcomes determine the degree of inquiry that teachers should employ (NRC, 2000).

This inquiry approach to teaching and learning allows the teacher to become more of a facilitator in the students' learning and the students to become more self-directed. As a result of this shift from a teacher-centered classroom to a student-centered classroom, students are to establish "long-term conceptual understandings of science" (Kleine et al., 2002, p. 39).

One of the problems with open inquiry, according to Settlage (2007), is that open inquiry is the purest form of classroom inquiry and suggests it is an ideal and an unrealistic aim for science teachers. He further states authors almost inevitably place open inquiry at the top of acceptable teaching methods but suggests that this myth needed to be dismantled. His reasoning for this position lies with his belief that it is impractical to expect teachers to implement open inquiry with any regularity (Settlage, 2007). Settlage does agree that the best definition of inquiry has been given by the NRC and its five essential features mentioned earlier.

Another problem with open inquiry that exists is the fact that many teachers have never experienced teaching or learning science by inquiry and therefore do not feel

confident in their own teaching (Kleine et al., 2002; Windschitl, 2002). Windschitl

(2002) believes that teachers themselves must experience first-hand how learning as

inquiry takes place in order to replicate the same lessons and activities with their own

students (Windschitl, 2002). He adds that when teachers become more effective teachers

as a result of teaching science by inquiry, they in turn promote the success of their

students in the area of science. Consequently, teacher inquiry-based professional

development program experiences are essential for change (Windschitl, 2002). Rakow

(1986) states the following:

> teaching science as a process of inquiry requires behaviors and attitudes that for
> many teachers are contrary to the ways in which they traditionally have taught
> and contrary to the ways in which they have been taught as students. In fact,
> difficulty in changing teacher behavior and attitudes has been a major impediment
> to the large-scale adoption of an inquiry approach to teaching science. (p.15)

Inquiry-Based Instruction

The major difference between the terms inquiry and inquiry-based instruction is

that inquiry-based instruction is the application of how inquiry is implemented in the

classroom. Colburn (2000) explains that inquiry-based instruction should include a

classroom where students are engaged in essentially open-ended, student-centered,

hands-on activities. King (1995) defines inquiry-based instruction as placing the

responsibility for learning on the student. Students learn a skill for asking questions on

their own. Students are not merely searching for correct answers to the instructor's

questions, they are posing and answering questions that address their own lack of

understanding.

According to the Ohio Department of Education (ODE),

> inquiry-based instruction in science is an active way for students to obtain
> scientific knowledge that involves all of the following in one way or another:
> making observations; identifying and asking valid and testable questions; gather
> information to see what is already known; reflect on appropriate scientific
> practices and procedures; use tools to gather, analyze and interpret data; use
> technology and mathematics to improve investigations and communications;
> organize, evaluate and interpret observations, measurements and other data;
> develop hypotheses and alternative explanations; and communicate ideas and
> results of investigation.

The components listed above encompass the expected inquiry-based teaching strategy
that should be employed in a laboratory experience science course (ODE, 2008).

Teachers have very different levels of knowledge and skills in science, ranging
from having only a high school level course completed or experienced teachers who are
certified in other teaching fields, to veteran science teachers or scientists who aspire to
teach but have a strong traditional science background. All are challenged by the need to
learn more or a different kind of science instruction. Teachers need to gain content
knowledge in an environment of inquiry-based instruction so they can put into practice
what they have learned. This teaching strategy is best implemented by beginning with
the exploration of a phenomenon and delaying the teaching of terms and principles until
they are needed. The NRC (2000) provides the following five possible ways to give
teachers first-hand opportunities of inquiry-based teaching:

- science subject matter and inquiry outcomes can be built into learning
  experiences
- deeper understanding of scientific concepts can promote discussion and
  the formulation of productive questions
- essential features of classroom inquiry can be woven into a learning
  experience
- the feeling of frustrations and struggle
- roles and behaviors instructors can use that promotes and support learning.
  (NRC, 2000)

Based on these definitions of inquiry and inquiry-based instruction, along with the literature that supports teachers' beliefs, self-efficacies and outcome expectancies, this study focused on the inquiry-based professional development program that provides science inquiry experiences.

Science Content Knowledge

Strong science content knowledge, in association with the proper use of teaching methods that promote science learning, is the cornerstone for effective science teaching (Posnanski, 2002). The science content knowledge and number of science courses completed plays an important role in the teachers' science teaching self-efficacy beliefs. Many researchers assert the necessity of having a strong science content background, as it relates to higher levels of science teaching self-efficacy beliefs (Borko & Putman, 1995; Butts, 1988; Oliver, 1995; Riggs, 1995; Shrigley, 1977; Shrigley & Johnson, 1974).

In addition, Shrigley and Johnson believe that strong science content knowledge helps establish higher levels of science teachers' self-efficacy beliefs by reducing anxiety about science teaching and promoting more positive attitudes toward science (Shrigley, 1977, 1983; Shrigley & Johnson, 1974). Other researchers have found that self-efficacy beliefs decrease, but levels of anxiety increase when science teachers gain content knowledge (Czerniak & Chiarelott, 1990; Westerback & Long, 1990). Ramey-Gassert and Shroyer (1992), and Coble and Koballa (1996) indicate that teacher attitudes toward teaching science and consequently their self-efficacy beliefs can be altered through professional development programs that focus on both learning and teaching science content.

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Loucks-Horsley et al. (1998) identify the critical need for content information to be included within professional development programs for science teachers (Loucks-Horsley et al., 1998). They further state that content conveyed to participants in a professional development program should include pedagogical content as well. Pedagogical content information includes knowledge about science content, student learning, forms of instruction and assessment, and science education reform (Loucks-Horsley et al., 1998; Smith, 2000).

Professional Development

The connection between beliefs and practice can be further established as part of science education reform, if teachers' beliefs underlying practice can be directly addressed through professional development to maintain sustained change (Levitt, 2002). The National Science Education Standards (NSES) (NRC, 1996) specifically state standards for professional development of science teachers. The following standards pertain specifically to this study:

> Professional Development Standard A: Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. (p.59)
>
> Professional Development Standard B: Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. (p.62)
>
> Professional Development Standard C: Professional development for teachers of science requires building understanding and ability for lifelong learning. (p.64)
>
> Professional Development Standard D: Professional development programs for teachers of science must be coherent and integrated. (p. 67)

There is a need for teachers to practice inquiry to learn its meaning, its value, and how to use it to help students learn. It is also important to have a community of teacher-learners. This community mirrors the scientific community because they challenge and support the development of knowledge by scientists, students and teachers (NSES, 1996). These professional development standards require teachers to continually improve themselves through professional development.

Long-term comprehensive inquiry based professional development is an absolute requirement for the success of standards-based reform (NRC, 2000). Teachers can develop their own understanding through inquiry as they investigate and participate in professional development programs. Professional development programs provide a coordinated support system that maximizes the staff's opportunity to grow and succeed in teaching science through inquiry (NRC, 2000).

Haney and Lumpe (1995), in proposing a framework for science teacher professional development, indicated that the identification of teachers' beliefs about science teaching is critical to the reform process. They added that change cannot occur until these beliefs about self-efficacy are addressed in the planning and training sessions of professional development.

Characteristics of Professional Development for Science Teachers

In addition to beliefs about the importance of self-efficacy being needed in order to address changes in science teaching, some researchers believe the length of the professional development program is crucial in determining the sustainability of the changes under investigation. Research in mathematics and science indicate that increased

student achievement is directly related to length as well as the type of professional development that teachers experience (Cohen & Hill, 2000; Louckes-Horsley et al, 2003; Supovitz & Turner, 2000). Supovitz and Turner (2000) found in their research that at least 80 hours of professional development are needed before a statistically significant relationship can be identified between professional development experiences and changes in teaching practice. Johnson, Kahle, and Fargo (2007b) explain that many professional development opportunities are not sustained, thus making change difficult.

Teacher education programs should be based on constructivist theories of learning and also reflect the K-12 Standards (Richardson, 1996). Richardson states that it is difficult to change teachers' beliefs but suggests that inservice teachers should experience constructive approaches from a learner's perspective, which will lead to having opportunities to reconstruct their beliefs based on their reactions as students.

Since the NRC (1996) has written the professional development standards, recent views of professional development promote a constructivist approach in the delivery of professional development programs. In a constructivist-based professional development program teachers develop the knowledge base to effectively analyze their teaching situation and choose from a variety of strategies to enhance teaching behaviors and student learning (Posnanski, 2002). Under a constructivist method of professional development teachers learn about science and science teaching with the same methods and strategies as students should learn science in schools.

Johnson, Kahle, and Fargo (2006) conducted a study of teacher effectiveness and student achievement in science, which demonstrates that effective teachers positively impact student learning. This study was conducted over a 3-year period, with 11 science

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teachers in a Midwestern state. Effective teaching was identified through a series of classroom observations using the instrument, Local Systematic Change Classroom Observation Protocol. Researchers found effective teaching increases student achievement and closes the achievement gap for all students. They also state that improved teacher effectiveness is sustained through collaborative, professional development, focusing on implementing standards-based instruction in science, also known as effective science instruction. They also explain that many science teachers lack experience with inquiry and have insufficient content knowledge to implement standards-based instruction effectively. Some have beliefs that are in opposition to standards-based instruction. The reality is that science teachers are at many places on the continuum of effective to ineffective instruction and therefore successful inquiry-based professional development programs are needed to assist teachers in becoming effective science teachers in order to increase student achievement in science.

Learning to teach science through inquiry can be done through professional development designed to help teachers teach through inquiry. Loucks-Horsley et al (1998) identified 15 strategies for professional development, some of which include: case discussions, examining students' work, action research, study groups, technology-based learning, curriculum implementation, coaching and mentoring and immersion in scientific inquiry. Loucks-Horsley's research suggests teachers studying by these methods build their knowledge of how their own students learn most effectively. These methods also provide teachers with learning experiences different from the more traditional college courses or inservice workshops previously provided. This type of

professional development focuses more on teacher practice, including organization and presentation of curriculum, student work and teachers' self evaluations.

Professional development should occur on a continuum. It must satisfy needs of all prospective and practicing teachers to continue to grow, increase knowledge and skills and improve their value. The NSES (1996) emphasizes the importance of life-long learning.

Attributes of effective professional development programs:

1. Professional Development programs offer coherent opportunities for teachers to learn over time. Teachers can apply it to their teaching with support of colleagues, schools and districts.

2. Effective Professional Development programs are a product of a collaboration of many people and organizations. They are partnerships between educators, universities and research institutions in creating opportunities for teachers to conduct scientific research.

3. All programs have a clear commitment to the vision of the NSES, which calls for giving teachers the knowledge and the abilities they need to address the science literacy needs of all their students.

Highly Qualified Teacher Status

As part of the national call for science teaching reform, there is an increased need for professional development programs that address teachers becoming highly qualified in their content area of teaching. The federal government has instituted a requirement for veteran teachers who possess a grades 1-8 certification and special education teachers to

become highly qualified in their content areas. This requirement of highly qualified

status stems from the No Child Left Behind (NCLB, 2001) act ensuring that all teachers

are highly quailed in their content area. In order to teach science, all teachers must

satisfy the new requirements of becoming highly qualified teachers in science. Since

many teachers need additional help in achieving highly qualified teacher status in

science, many professional development providers are looking at generating opportunities

for teachers to become highly qualified. Each state determines what its definition of

Highly Qualified Teacher (HQT) status means and how the components fulfill this

requirement. This requirement in Ohio can be met in one of the following ways: a

teacher has a minimum of a bachelor's degree, full state certification/licensure, and one

of the following:

1. Passage of Ohio's State Licensing Exam,

2. Academic major or 30 credit hours in a content area,

3. A Master's degree,

4. 8-year Professional certificate,

5. Permanent certificate,

6. National Board Certification,

7. HQT Rubric- scored 100 points or more, or

8. 90 hours completed in an approved professional development program
   (ODE, 2008).

The Education Trust study reported for Ohio, that 4 out of 10 teachers in the

state's high minority and high poverty secondary schools are not considered highly

qualified in science (Peske & Haycock, 2006). In addition, only one in eight elementary

school teachers is considered highly qualified in science (Peske & Haycock, 2006). Because of this reality, the professional development providers of this study will provide an intense 120 hours of inquiry-based professional development so that participating teachers will satisfy the requirements of the federal law and become Highly Qualified Teachers in science. Therefore, one way to insure highly qualified teachers in science is through intensive professional development.

CHAPTER III

METHODOLOGY

Introduction

This chapter reviews the details of the overall methodology used in this study. Included in this chapter are the research hypotheses, demographics of the participants, variables, research design, a detailed review of the instruments, history of the usage of the instruments, data analysis, and the internal and external threats to the validity and reliability of the study.

Purpose

The purpose of this study was to investigate the change of inservice teachers' self-efficacies and outcome expectancies of science teachers after participating in an inquiry-based, professional development program. In addition, the researcher reported if the science education background, professional position, number of years taught, and teacher qualification status significantly contribute to science teachers' self-efficacies and outcome expectancies.

Research Questions

This research examined whether there is a change in self-efficacies of participating science teachers after attending an inquiry-based professional development program. Four research questions are included in this study.

Research Question 1. Is there a change in self-efficacies measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program?

Research Question 2. Is there a change in outcome expectancies measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program?

Research Question 3. Is there a relationship between science teachers' self-efficacies measured by STEBI-Form A and science education background, professional position, number of years taught, and teacher qualification status?

Research Question 4. Is there a relationship between outcome expectancies measured by STEBI-Form A and science education background, professional position, number of years taught, and teacher qualification status?

<div align="center">Research Hypotheses</div>

Previous studies indicated that science teachers' self-efficacies and outcome expectancies can be changed through inquiry-based instruction and professional development training (Brown & Melear, 2006; Loucks-Horsley et al., 1998; Lumpe, Haney & Czerniak, 2000). Factors such as science education background, professional position, number of years taught, and teacher qualification status contribute to self-efficacy and belief systems (Hofer & Pintrich, 1999; Olafson & Schraw, 2006). Based on the literature of science teacher professional training programs, four research hypotheses are developed in this study:

1. There is a significant overall gain in self-efficacies measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

2. There is a significant overall gain in outcome expectancies of students' learning measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

3. Science education background, professional position, number of years taught, and teacher qualification status are significant contributing factors to science teachers' self-efficacies.

4. Science education background, professional position, number of years taught, and teacher qualification status are significant contributing factors to science teachers' outcome expectancies.

Null Hypotheses

The null hypotheses are generated from the research hypotheses for statistical testing purposes:

1. There is no significant overall gain in self-efficacies measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

2. There is no significant overall gain in outcome expectancies of students' learning measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

3. Science education background, professional position, number of years taught, and teacher qualification status are not significant contributing factors to science teachers' self-efficacies.

4. Science education background, professional position, number of years taught, and teacher qualification status are not significant contributing factors to science teachers' outcome expectancies.

For the above null hypotheses, Type I error was set at the 0.50 level. Type II error was set at the 0.20 level resulting in a power of 0.80 for hypothesis testing (Cohen, 1992).

Research Design

The researcher applied quasi-experimental design to guide the data collection and data analysis procedures for this study. Campbell and Stanley (1963) refer to experiments that lack random assignment of participants as quasi-experiments. According to Gall, Gall, and Borg (2007), quasi-experimental designs are used when random assignment of research participants to experimental and control groups is not possible. The most commonly used quasi-experimental design in educational research is the nonequivalent control-group design. In this design, research participants are not randomly assigned to the experimental and control groups and both groups take a pretest and posttest. A variation is that all groups receive the treatment in the research (Gall et al., 2007).

Gall et al. (2007) describe the essential features of a quasi-experimental design as the following:

1. Nonrandom assignment of research participants to groups.

2. Administration of a pretest to all groups (the pretest is used as a benchmark for the study).

3. Administration of the treatment to the groups involved.

4. Administration of the posttest to all groups.

Gribbons and Herman describe quasi-experimental designs as being especially useful in addressing questions about the effectiveness and impact of programs (Gribbons & Herman, 1997). They further explain that quasi-experimental designs increase our confidence that observed outcomes are the result of a given program or innovation instead of extraneous variables or events. As stated earlier, Gribbons and Herman concur

along with Heppner (1992) that quasi-experimental designs are commonly employed in the evaluation of educational programs when random assignment is not possible. Researchers recommend using a quasi-experimental design for assessing new curriculum and in the event that a better design is not feasible (Campbell & Stanley, 1963; Newman & Newman, 1994).

Quasi-experimental design was the most appropriate for this study because the assignment of the teachers participating in this professional development program was not random. In addition, because the researcher wanted to examine if there is a change in science teachers' self-efficacies and outcome expectancies of student learning as a result of this inquiry-based professional development program, it was necessary that a pretest and posttest be given, thus utilizing the nonequivalent category of quasi-experimental design. In comparison with Gall et al. (2007) three data points were then determined; pretest, posttest, and follow-up posttest. All participants received the intervention, -- the 15- week long inquiry-based professional development program – thus satisfying all essential features of a quasi-experimental design.

Implementation Procedures of Inservice Teacher Professional Training

The professional development training program was funded by the Office of Curriculum and Instruction Mathematics and Science Partnerships Program Grants through a Midwestern university. The vision of this program was to improve the teaching and learning of the science academic content standards for inservice teachers and help them to become highly qualified teachers of science. Specifically, the program focused on: (1) implementing effective instructional practices by raising the self-

efficacies of participants when implementing inquiry-based lessons, and (2) improving

student performance in science by raising the outcome expectancy teachers have toward

their students learning. In addition, these goals were implemented in order to give the

participants an opportunity to become highly qualified teachers in science.

Teams of 3rd through 10th grade science teachers from high-need districts in the

region participated in the inquiry-based professional development program. High-need

districts are those that have student passage rates below 75% on state tests, have a higher

than average number of students from low-income families, or employ a large number of

teachers who do not have "Highly Qualified Teaching" (HQT) status in their teaching

area. Superintendents received a partnership agreement asking for commitment to

supporting this program by achieving participation of at least 50% of the eligible teachers

in the grade band of a school building. Having this number of teachers trained would

potentially have an impact on programmatic changes within a building and district. A

rubric determined the order of teachers' acceptance into the program. Preference was

given to teachers in buildings with the lowest student achievement scores, the highest

numbers of students from low-income families, the greatest number of teachers who did

not have Highly Qualified Teaching status (HQT) in their teaching area, and teachers

who were members of building teams. Principals and superintendents recruited teachers

to participate in the professional development training program held in a university

setting.

The inquiry-based professional development program in this study included 86

teachers who taught in grades 3-10. Based on curriculum topics participants were

segmented into five sections by grade level: grades 3 - 4, grade 5, grade 6, grades 7 - 8,

and grades 9 - 10. During the first summer workshop (2007), each session spanned a 2-week period of five 8-hour days per week, totaling 80 hours of face-to-face interaction as the first part of the intervention. Then the participants went back to teach in their own classrooms where they had the opportunity to apply what they learned. This was the second portion of the intervention. The third phase or follow-up intervention occurred the following summer when participants had the opportunity to learn more inquiry-based teaching strategies to employ in their classrooms.

A typical day started with the professional development providers asking the participants an inquiry-based science question. This question was based on the appropriate grade level science academic content standard that was to be covered in that day's session. Instructors provided materials for the teachers to experience learning, as their students should, by investigating the question according to a learning cycle model in order to address the opening inquiry-based science question.

Participants worked in groups of four to five, investigated an inquiry question, collected data, analyzed the data, and reported their findings back to the whole class. The professional development provider led a class discussion on the procedures participants used and results gathered. Participants had an opportunity to discuss with each other their successes, challenges, adaptations, and how they could incorporate these inquiry-based lessons into their curriculum. Instructors also gave background content information pertinent to each activity along with real world applications that could be discussed with the participants' students.

On Day 1, each of the five sections with grade bands (grade 3/4, 5, 6, 7/8 and 9/10) had different science content standards introduced to the participants

simultaneously. Each section based on the grade level began its session by first

pretesting the participants in content knowledge with a grade specific content knowledge

test with questions that students at their grade level should be able to answer. In addition

the participants answered questions on the STEBI-Form A to set up baseline data for their

initial self-efficacies and outcome expectancies. Next, all participants discussed an

overview of the entire professional development program, tools of science, inquiry,

science process skills, learning cycle, the Standards, concept maps, and assessments for

learning.

Typical Day

For grade 5 participants, a typical day started with an activity, "Neighborhood

Ecosystems Come Alive." During this activity, participants in groups of four or five

chose an area outside the building to discuss: "How do we know what is living and non-

living in an ecosystem?" Each group went outside to rope off their own three foot

diameter area and made observations of all living and non-living objects found in that

area. Many participants made drawings of their observations as well as detailed notes.

Participants returned to their area the following week for additional observations and

noted changes in the area which would be compared to initial observations. From these

two sets of observations, participants inferred what seasonal changes would take place in

their area over time. The groups reconvened in the classroom to discuss their findings,

comparing and contrasting each group's ecosystem. Each group identified the living and

non-living items in the ecosystem which led to a lively discussion between participants

concerning a tree stump and its living or non-living categorization. One of the

participants utilized a computer in the room for help in determining the tree stump status. This discussion led to two new terms related to this topic, biotic, and abiotic. Participants were now able to make the connection between living, non-living, biotic, and abiotic in order to correctly classify the tree stump's identification. In order to assess this activity, the participants copied an article from a newspaper or magazine that described an ecosystem which has experienced changes. Examples could include forest fires, a hurricane, and a flood in the Mississippi Valley just to name a few. For another assessment participants created a poster or brochure, where the purpose was to help citizens understand the effects (positive or negative) that changes are having on the ecosystem. Questions addressed on the poster could include: What has occurred that created change in the ecosystem? Did this change benefit the ecosystem? What happened to the population of living organisms (increasing or decreasing)? Are there any clear alternatives to these changes and if so, what are there possible consequences? Finally, the participants discussed their likes, dislikes, and possible changes they would make to this activity when they implement it in their own classroom.

After participants completed the activity, the instructor then aligned each activity to specific content standards, a detailed lesson summary, student prerequisite knowledge – what previous knowledge students should know before starting this investigation, time needed for lesson implementation, materials, safety, procedure notes, explanations, student worksheets, and references. At the conclusion of this activity, the instructor discussed applying the learning cycle to the implementation of this activity in the participants own classrooms. This activity was designed to not only improve the participants' content knowledge base, but also provided an opportunity for them to

experience an inquiry-based lesson and feel confident in delivering this lesson to their own students. Activities like the aforementioned were intended to increase content knowledge, build confidence, and consequently self-efficacy and outcome expectancy in the participants teaching abilities. Additional lessons and topics covered in the fifth grade band may be found in Appendix E.

Implementation Phase

During the following school year, participants made a commitment to implement these activities into their own classrooms after this intense 2-week summer workshop (2007). At scheduled dates throughout the school year, two days in September, two days in January, and one day in April, participants came back to the university for all day inquiry-based sessions to discuss with one another the positive experiences and challenges experienced when implementing summer workshop activities with their own students. Participants also engaged in additional activities covering science academic content standards not discussed during the first summer sessions.

Finally, the participants finished the last 40 hours of additional science education during the second summer workshop (2008), following the year-long implementation period between the two summer workshops. Activities in this second summer workshop (2008) focused on science academic content standards and inquiry-based teaching strategies that were not addressed in the first 80 hours or doing the school year sessions.

Each participant received $105 per day for 10 days in their first summer (80 contact hours) and $105 per day for 5 days in their second summer (40 contact hours) for completing the professional development program, not for completing the surveys for this

study. As a result of participation, teachers obtained credits towards their license renewal and teacher qualification status of science.

<div align="center">Demographic Description of the Participants</div>

Participants in this study represented a convenience sample of 86 inservice teachers in the professional development program (Gall et al., 2007) because they were not randomly chosen to participate in this study; rather they were readily available to participate in this inquiry-based professional development program because of the school districts' involvement in the program. The participants represented science teachers that come from high-need districts. Many of the teachers participated in this program to receive teacher qualification status on their teaching certificate/license. Upon receiving the status of teacher qualification status in science, the participants comply with state mandates that all teachers who teach science be highly qualified in the content area.

The 86 participants who attended were divided into five grade level groups: grades 3 - 4 (31 teachers), grade 5, (22 teachers), grade 6 (9 teachers), grades 7 - 8 (13 teachers) and grades 9 - 10 (11 teachers). The majority, 79% of participants were female, while 21% were men across all grades in this program. The grades 3 - 4 teachers had the most experienced teachers, having taught an average of 18 years. Grade 5 teachers taught 12 years on average, grade six teachers averaged 9 years, grades 7 - 8 teachers averaged 10 years, and the grades 9 - 10 teachers had the least amount of experience with an average of 7 years taught. Of the professional positions that the participants currently hold: intervention specialist or classroom teacher, one tenth of the participants were intervention specialists. All others were classroom teachers. Sixty-six percent of the

participants were highly qualified in science at the start of the professional development program while 34% were not highly qualified in science. The number of college science courses that participants self-reported as having completed prior to this inquiry-based professional development program ranged from one to more than 20. Participants who taught grades 9 - 10 reported having the highest average of college courses completed (11). Grades 3 - 4 and grade 5 participants averaged six science courses completed, grades 7 - 8 participants averaged nine courses completed and grade 6 participants had the lowest average with five courses completed. All of this demographic information is presented in Table 3.1.

Table 3.1

Demographics

Demographics	Grades 3/4	Grade 5	Grade 6	Grades 7/8	Grades 9/10
Male	4	3	1	4	6
Female	27	19	8	9	5
Average years taught	18	12	9	10	7
Intervention specialist	3	3	5	5	2
Classroom teacher	28	19	4	8	9
HQT	16	14	6	12	9
Non-HQT	15	8	3	1	2
Average college science courses completed	6	6	5	9	11

The Ohio Department of Education (ODE) has classified school districts according to certain demographic information in order to provide a basis for comparisons of school districts. The following list provides a brief explanation of each group that is represented in this study:

- Rural/Agricultural 1 – high poverty, low median income

- Rural/Agricultural 2 – small student population, low poverty, low to moderate median income

- Rural/Small Town 3 – moderate to high median income

- Urban 4 – low median income, high poverty

- Major Urban 5 – very high poverty

- Urban/Suburban 6 – high median income

Table 3.2 summarizes the school districts in which the participants of this study are employed. The majority (40%) of their students reside in the Urban 4 category which includes urban (high population density) districts that encompass small or medium size towns and cities. They are characterized by low median incomes and very high poverty rates (ODE, 2008).

Table 3.2

Typology of School District Participants

Typology of school districts	Number of participating school districts
Rural 1	7
Rural 2	6
Rural 3	1
Urban 4	11
Urban 5	2
Urban 6	2

Sample Size

A total of 86 inservice teachers participated in and completed the inquiry-based professional development program. Eighty-six participants responded to STEBI-Form A via WebCT as pretest on the first day of the program session. Seven participants were not present on the day when participants were asked to respond to STEBI-Form A for the posttest due to personal reasons at the end of the 2 week professional development training. Seventy-three participants finished responding to STEBI-Form A the third time as a follow-up posttest. As a result only 60 participants completed the self-efficacy instrument all three times that was needed for repeated measure data analysis.

Cohen (1992) has suggested that quasi-experiments should strive to obtain a power of 0.80 to control for type II error. The researcher in this study decided to use the traditional 0.05 threshold to determine Type I error. Type 1 error is the rejection of the null hypothesis when it is true. Type II error is the acceptance of the null hypothesis when it is false (Gall et al., 2007). Researchers have complete control over type I errors by resetting the alpha value. Type II errors are not as directly controlled because they are related to the sample size. For example, as the number of participants increase, the type II error decreases. Ideally, researchers want to minimize both type I and type II errors in a study in order to increase the validity of the study. The effect size estimation is based on planned contrasts. The researcher in this study expected there would be a medium effect size, meaning there would be a medium effect size change before and after the inquiry-based professional development program. Usually the number of sufficient sample size to yield a reasonable reliable statistical result is determined by three indicators (a) type 1 error, (b) type 2 error, and (c) effect sizes (Cohen, 1992).

In reference to Cohen's recommendation (1992) to determine the sample size considering a power of 0.80, with 0.05 type 1 error with medium effect sizes, the required sample size for repeated measure with three groups is $n = 64$. The sample size in this study was 60, below the required minimal sample size needed for such statistical analysis. For multiple regression analysis, with four predictors, type 1 error of .05, and power of .80 require sample size of 64, which was lower than the required minimal sample size needed for such statistical analysis. Because of the low sample size, the researcher was cautious in looking at both statistical significance and practical significance and fully aware of the limitations to draw certain conclusions.

Instruments

Participants in this study completed STEBI-Form A, at three time intervals, on the first day of the summer workshop (2007), 8 months after classroom implementation, and on the last day of the second summer workshop (2008) at the end of the program. The Demographics Survey was administered only on the first day of the first summer workshop (2007). A copy of STEBI-Form A is included in Appendix D. The Demographics Survey is included in Appendix B.

Demographics Survey

The Demographics Survey is a self-reported questionnaire that collected information regarding the following variables: gender (female or male), professional position (intervention specialist or classroom teacher), number of years teaching, teacher qualification status in science (yes or no), and science education background (number of college science courses completed). Participants completed the Demographics Survey

(developed by the researcher) only once on the first day of the inquiry-based professional development program in the first summer workshop (2007). No demographic posttests or follow-up posttests were administered.

Science Teaching Efficacy Belief Instrument – STEBI-Form A

The Science Teaching Efficacy Belief Instrument (STEBI-Form A) measured participants' self-efficacies and outcome expectancies. Iris M. Riggs in 1989 first published the STEBI (Riggs, 1988). It was further developed by Riggs and Larry Enochs in 1990, into its current form (Enochs & Riggs, 1990). There are two forms of this instrument: Form A, which is designed for current teachers and Form B, which is designed for preservice teachers. The researcher used STEBI-Form A to measure self-efficacy and outcome expectancy because all participants were practicing science teachers.

Self-efficacy was defined by Bandura as a behavior based upon two conditions; people's beliefs in their own ability to perform behaviors (self-efficacy), and people's expectations regarding certain behaviors to produce desirable outcomes (outcome expectancy) (Bandura, 1977a). The instrument was specifically designed to measure science teaching self-efficacy as reported in the two subscales, the Personal Science Teaching Efficacy (PSTE) and the Science Outcome Expectancy (STOE). PSTE subscale measures a person's belief in his or her ability to do what needs to be done in order to bring about a desired result. The total score possible for the PSTE subscale is a 65. STOE subscale measures the belief that teaching has a profound effect on student learning (Cantrell, 2003). The total score possible for the STOE subscale is 60. The

authors of the STEBI (Enochs & Riggs, 1990) state, "Behavior is enacted when people not only expect specific behavior to result in desirable outcomes (outcome expectancy), but they also believe in their own ability to perform the behavior (self-efficacy)" (p. 2). The STEBI-Form A keeps the construct of teacher self-efficacy and outcome expectancy distinct in order to evaluate both separately.

The STEBI-Form A consists of 25 Likert scale items investigating two dimensions of self-efficacy. The 25 statements ask the respondent to answer in categories of Strongly Agree (SA), Agree (A), Uncertain (U), Disagree (D), and Strongly Disagree (SD) for both subscales. The STEBI consists of 13 positively and 12 negatively stated statements; therefore, two scales are used when analyzing the results. For positively written statements the values for each response are: SA = 5, A = 4, U = 3, D = 2 and SD = 1. For the negative responses the scoring is reversed: SA = 1, A = 2, U = 3, D = 4 and SD = 5 (Enochs & Riggs, 1990). According to the authors of the STEBI, "Reversing these items will produce high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs" (Enochs & Riggs, 1990, p .30).

Reliability of STEBI-Form A

The test developers reported Cronbach reliability coefficients to determine internal reliability for both scales. The reliability of any instrument is calculated by a reliability coefficient (Gall et al., 2007). Reliability coefficients usually range between 0.00 and 1.00. The higher the value, the more reliable the instrument, free of errors (Gall et al., 2007). A Cronbach alpha specifically measures the internal consistency of test

items based on the respondents' answers and how they respond to specific statements that are stated in similar ways.

Enochs and Riggs performed a Cronbach reliability coefficient on both subscales of this instrument. For the Personal Science Teaching Efficacy Belief Scale (PSTE), coefficient alpha = 0.92 (p = 0.05) and for the Science Teaching Outcome Expectancy Scale (STOE), coefficient alpha = 0.77 (p = 0.05) (Enochs & Riggs, 1990). Enochs and Riggs believed this lower value for the STOE subscale seemed adequate based on the construct, which past researchers have had difficulty defining and measuring. The authors suggested a lower reliability might also be due to multiple variables contributing to the construct. The authors stated: "This lower reliability might be due to multiple variables contributing to the construct as defined by the item set. For example, teachers' science background, inadequacy of students' science background, and low-motivated students." (Enochs & Riggs, 1990, p. 633). In addition, Riggs and Enochs (1990) also state, "Teachers may more consistently evaluate their own personal behaviors as in the Personal Science Teaching Efficacy Belief scale than to decide possible outcomes dependent upon what they may view as external factors" (p. 633).

Validity of STEB-Form A

Evidence of validity for STEBI-Form A is reviewed from four aspects. These are face, criterion, construct, and content validity (Gall et al., 2007). Face validity assures that the items "look as though they measure what is important" (Gall et al., 2007, p. 193). Face validity is a causal look or subjective overview to see if the items are truly measuring what is intended to be measured. Criterion validity of an instrument is

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established when the developers are able to use an outside source or measurement that is related by an individual variable or criterion to measure the behavior under investigation. Construct validity is "the extent to which a measure used in research correctly operationalizes the concepts being studied" (Gall et al., 2007, p. 477). Usually construct validity is used for a certain trait or personality that the researcher would like to measure, in this case it is self-efficacy. Content validity is explored at the instrument developmental stages because the constructs being studied must have appropriate constitutional and operational definitions in order to measure what is intended to be measured on a particular instrument. Content validity is important to ensure that all of the content that the researcher is interested in measuring clearly appears on the instrument.

For face validity, the STEBI authors piloted the instrument in the construction and validation phase of the scale by taking the revised scale, which consisted of 29 items and administered it to a sample of 331 practicing elementary teachers in Kansas and Kansas City school districts and performed item analysis on the results. "Items which did not have a high positive discrimination index were rejected" (Riggs & Enochs, 1990, p. 629). The 25 items on the final version of the survey seem to be measuring the construct that was under investigation (Riggs & Enochs, 1990).

Criterion validity was established for this instrument by evaluating seven other self-report items. Using self-reported items of: (a) years spent teaching at the elementary level, (b) subject preferred, (c) time spent teaching science, (d) utilization of activity based science instruction, (e) acceptance of responsibility for science teaching, (f) self-rating of effectiveness in science teaching, and (g) an appraisal of science teaching

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effectiveness by the principal, researchers calculated and assessed a Pearson Product-Moment Correlation. The researchers assessed and reported responses as Pearson's *r* for the seven criteria. All criteria assessed were significantly correlated with at least one scale and were in a positive direction.

Construct validity is determined by way of factor analysis by showing a correlation between the two scales incorporated, the Personal Science Teaching Efficacy Belief Scale and the Science Teaching Outcome Expectancy Scale. The authors state, "All criteria assessed within the major study were significantly correlated with at least one scale and were in a positive direction. These results provided good general support for the construct validity of the scales" (Riggs & Enochs, 1990, p. 632). The two scales positively correlated with an *r* value = 0.19 at the level $p < 0.01$ (Riggs & Enochs, 1990).

Lastly, expert judges edited items for clarity and rated the entire scale for accuracy to determine content validity. Items that were inconsistently classified by more than half the judges were eliminated (Riggs & Enochs, 1990). A psychometric review provided evidence to support that STEBI-Form A is a reliable and valid instrument for inservice science teachers' self-efficacy.

History of Using STEBI-Form A

Accessing Educational Resources Information Center (ERIC), Dissertation Abstracts, Google Scholar, and Education Research Complete databases using the keywords STEBI, 15 studies were found that used the STEBI to conduct research in the science education field. Seven of the studies used the STEBI-Form B (the preservice version), while eight studies used the STEBI-Form A (inservice version). These studies

were published during 1995-2004 with the STEBI-Form A used to measure science

teachers' self-efficacy. Table 3.3 presents a summary of the published studies using

STEBI-Form A during these years and summarizes the results arranged chronologically,

beginning with the most recent. Because STEBI-Form A is the instrument used in this

study, only related studies using the same instrument are reported in Table 3.3. Of the

eight studies using STEBI-Form A, one study was completed over a length of time longer

than a 2-week workshop (one year). The other studies focused on short inservice

programs lasting from 4 days to 2 weeks. The general outcome of the scores ranged from

44.84 to 64.57 on the PSTE subscale and 25.42 to 49.97 on the STOEsubscale. Five

studies reported mean scores for PSTE subscale and STOE subscale, two studies reported

mean gained, and one reported results as *t*-tests scores. Table 3.3 presents a summary of

the eight studies using STEBI-Form A including the years of publication, the author and

title of the publications, sample size (N), and pre and post results for both PSTE and

STOE subscales.

Table 3.3

Summary of the Studies Using STEBI-FORM A

Year, Author	Title of Study	N	Subscales PSTE – Pre	Subscales PSTE – Post	Subscales STOE – Pre	Subscales STOE - Post
2004 Khourey-Bowers, C.; Simonis, D.	Longitudinal Study of Middle Grades Chemistry Professional Development: Enhancement of Personal Science Teaching Self-efficacy and Outcome Expectancy	135	t-tests Pre-Post -5.176		t-tests Pre-Post -3.700	
2003 Eshach, H.	Inquiry-Events as a Tool for Changing Science Teaching Efficacy Belief of Kindergarten and Elementary School Teachers	30	Mean Gained 3.45	Mean Gained 3.94	Mean Gained 3.95	Mean Gained 4.45

Table 3.3

Summary of the Studies Using STEBI-FORM A (continued)

Year, Author	Title of Study	N	Subscales PSTE – Pre	Subscales PSTE – Post	Subscales STOE – Pre	Subscales STOE - Post
2002 Posnanski, T.	Professional Development Programs for Elementary Science Teachers: An Analysis of Teacher Self-efficacy Beliefs and a Professional Development Model	43	44.71	51.48	41.74	42.97
2001 Roberts, J.; Henson, R.; Tharp, B.; Moreno, N.	An Examination of Change in Teacher Self-efficacy Beliefs in Science Education Based on the Duration of Inservice Activities	41	46.95	53.53	Not Reported	Not Reported
2000 Stewart, M.	The Evaluation of Professional Development Training for Elementary Teachers in Urban and Native American SchoolsUsing Design Technology and the Learning Cycles	32	47.66	55.81	41.84	46.11
2000 Lumpe, A.; Haney, J.; Czerniak, C.	Assessing Teachers' Beliefs about Their Science Teaching Context	262	47.56		41.29	
1998 Marion, V.	An Analysis of the Relationship Between Teachers' Acquisition of Physics Content Knowledge and Their Level of Science Teaching Efficacy	61	Mean Gained 7.02	Mean Gained 3.78	Mean Gained 1.40	Mean Gained -0.22
1995 Khourey-Bowers, C.	Enhancing Teacher Effectiveness in Science Education Through Enactment of a Conceptual Change Model of Professional Development	40	47.25	53.13	41.34	40.41
1995 Czerniak, C.; Lumpe, A.	Relationship Between Teacher Beliefs and Science Education Reform	168	Means were not reported – Used in Multiple Regression			

Data Collection

All 86 participating teachers in the inquiry-based professional development program were contacted by the researcher. The researcher is also the external program evaluator for this grant. All teachers agreed to become participants in this study by

signing a consent form describing the nature of this study and being assured of complete

anonymity and confidentiality. A sample consent letter may be found in Appendix A.

This research was approved by the Institutional Review Board (IRB) through the

researcher's university in order to protect all human subjects involved in this study

(Appendix A).

The participants completed both the Science Teaching Efficacy Belief Instrument

(STEBI-Form A) and the Demographics Survey on the first day of the professional

development program, which took place in the summer of 2007. Participants completed

the STEBI-Form A on the first day of the first summer workshop (pretest), a second time

8 months after implementation with their own classrooms (posttest), and a third time at

the end of the second summer workshop (follow-up posttest). The pretest established

baseline data information before the inquiry-based professional development program

began to measure initial self-efficacies and outcome expectancies (Gall et al., 2007). The

posttest, administered in the spring of the school year following the summer term, was

given to measure changes that might take place as a result of the participants having had

time to implement the inquiry activities from the summer program in their own

classrooms. The follow-up posttest was given on the last day of the second summer

session (2008) after 40 more contact hours of instruction with the professional

development providers. The professional development providers of the program

administered the STEBI-Form A and instructed participants to complete the surveys

using computers provided by the university in the computer labs on campus where the

program took place. Participants utilized WebCT, a learning management system, to

complete STEBI-Form A and the Demographics survey. All participants chose their own

identification code that they affixed to all documents to ensure confidentiality. Only the

Principal Investigators (PI's) of this inquiry-based professional development program had

direct access to the responses on WebCT. The PIs printed out the survey responses with

identification codes affixed and transferred the information to the researcher. Since this

researcher was not comparing gain scores individually over time, none of the

identification codes was used except to check participants who had completed all three

STEBI-Form A surveys.

Data Analysis Methods

In this study, repeated measure and multiple regression were applied to conduct

statistical analysis. The researcher decided to apply these two statistical analyses

methods based on the research hypothesis and the characteristics of the measurement

variables included in the study. In the following sections, a description of the variables

included in the study and the measurement scales of these variables are presented. The

purpose of presenting a list of the variables and their measurement types was to justify

the data analysis methods, namely repeated measure and multiple regression.

Variables of Interest in the Study

The dependent variables in this study were self-efficacy and outcome expectancy

measured by the STEBI-Form A. The dependent variable is "an attribute or characteristic

that is dependent on or influenced by the independent variable. They may be called the

outcome, effect, criterion, or consequence variables" (Creswell, 2002, p. 136). The

composite score of 13 items on the PSTE subscale, questions: 3, 5, 6, 8, 12, 17, 18, 19,

21, 22, 23, and 24 was used as self-efficacy measure. The total composite PSTE score

was 65. The total composite score of 12 items on the STOE subscale, questions: 4, 7, 9, 10, 11, 13, 14, 15, 16, 20, and 25 was used as outcome expectancy measure. The total composite STOE score was 60.

The independent variables in this study were the three time points for participating in the program (beginning, middle, and end), professional position, years taught, number of college science courses completed, and highly qualified teacher of science status. Norusis (2002) states, "An independent variable is a variable that is thought to influence another variable, the dependent variable" (p. 143). Categorical variables are those variables that can be measured as a nominal scale. Categorical variables in this study were time, professional position, and highly qualified teacher of science status. Continuous variables are variables that can assume any value along a continuum. Continuous variables in this study were years taught and science education background because for these participants the number of years taught ranged from one to over 30 years and the science education background spanned from one course to over 20. Table 3.4 presents the dependent variables, independent variables, and how they were measured in coordination with each research question.

Because of the variables under investigation in this study the researcher chose repeated measure and multiple regression statistical tests:

Table 3.4

Table of Independent and Dependent Variables in Study

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		Variables	Measured Scale
Research Question 1.	Dependent Variable	self-efficacy – composite score of PSTE	continuous
	Independent Variable	time	categorical
Research question 2.	Dependent Variable	outcome expectancy – composite score of STOE	continuous
	Independent Variable	time	categorical
Research question 3.	Dependent Variable	self-efficacy – Follow-up PSTE	continuous
	Independent Variable	1. professional position 2. number of years taught 3. teacher qualification status in science 4. science education background	1. categorical 2. continuous 3. categorical 4. continuous
Research question 4.	Dependent Variable	outcome expectancy – Follow-up STOE	continuous
	Independent Variable	1. professional position 2. number of years taught 3.teacher qualification status in science 4. science education background	1. categorical 2. continuous 3. categorical 4. continuous

_____

Repeated Measure

Leech, Barrett, and Morgan (2005) state, "When each participant is assessed more than once, these designs are referred to as repeated measures designs" (2005). Comparing performance on the same dependent variable assessed before and after the treatment (pretest and posttest) is a common example of a repeated measure designs. Leech et al. recommend that repeated measure designs be used in longitudinal research

such as this study since the professional development program takes place over a 15-month time frame (Leech et al., 2005).

Three data points were collected for the same participants and the purpose of the statistical analysis was to determine the trend of change on self-efficacy beliefs before, in the middle, and after the participation of the professional development training. The statistical test, repeated measure is used when a single group is measured several times (Black, 1999). Repeated measure calculates the change of treatment each time completed. The researcher chose repeated measure to analyze hypotheses one and two to examine the difference in group mean scores on both the PSTE and STOE subscales to determine any change from the three times it was administered (pretest, posttest, and follow-up posttest).

Multiple Regression

According to Mertler and Vannatta (2004), multiple regressions are "looking at the existence of predictable relationships among a set of variables. The purpose of regression analysis is a means of explaining causal relationships among variables" (p. 167). Multiple regression is an extension of simple linear regression because it involves more than one variable, specifically in this study, the number of college science courses completed, professional position, years taught, and highly qualified teacher of science status. Black (1999) explained there are situations where researchers wish to examine the nature of the relationship between a dependent variable and more than one independent variable. In these situations, Black suggests using multiple regression as the analytical tool for data analysis. The researcher chose multiple regression for hypotheses three and

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four to examine correlations between the results of the STEBI (PSTE and STOE subscales) and their relationship with the variables under investigation, number of years taught, teacher qualification status in science, professional position, and science education background. Furthermore, the researcher would be able to examine the results of interrelationships between the dependent variable and independent variables to test if the various participant characteristics such as the number of years taught, teacher qualification status in science, professional position, and science education background were significant predictors for inservice teachers' self-efficacy and outcome expectancy about teaching science.

Data Analysis Procedures

The researcher first took the answers supplied by the participants on WebCT in A, B, C, D, E form and converted all answers to 1, 2, 3, 4, 5 accordingly to put in numerical form for calculating mean scores. The positive statements were scored 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree. The negative written statements were scored in the reverse: 5 = Strongly Disagree, 4 = Disagree, 3 = Undecided, 2 = Agree, 1 = Strongly Agree. Next, the entire STEBI was separated into the two subscales; PSTE – items 3, 6, 8, 17, 19, 21, 22, and 24 and the STOE – items 1, 4, 7, 9, 10, 11, 13, 14, 15, 16, 20,and 25. Each participant had a composite score for both subscales. Using Statistical Package for the Social Sciences, SPSS 16.0 for Windows, two repeated measure analyses were conducted to determine participants' PSTE composite scores and STOE composite score changes during these three time series. The mean values and standard deviations for each subscale were calculated for the pretest,

posttest, and follow-up posttest. The mean differences were calculated to compare

pretest, posttest, and follow-up posttest. The researcher analyzed the PSTE and STOE

scores by comparing pretest, posttest, and follow-up posttest means as aggregate data.

Both quadratic and linear changes were examined. A p value and significant value for

both linear and quadratic trends determined magnitude of change over time. The effect

size was calculated for degree of change. A statistically significant outcome does not

give information about the strength or size of the outcome. Therefore, in addition to

information on statistical significance, the size of the effect is also important to calculate.

Effect size is defined as the strength of the relationship between the independent variable

and the dependent variable (Leech et al., 2005). Effect size is calculated by taking the

difference between mean scores on the pretest and posttest and dividing this value by the

standard deviation:

$$Es = \frac{x1 - x2}{sd}$$

Multiple regression analyses were then conducted to see if the demographic

variables explained participants' change in self-efficacies and outcome expectancies.

The dependent variable was the follow-up posttest of the PSTE subscale and the STOE

subscale. The researcher chose the follow-up posttest for analysis because this

measurement is considered to be the exit gain after participating in the inquiry-based

professional development program.

Before multiple regressions were applied to hypotheses three and four, the

researcher calculated a Pearson's coefficient (two-tailed) to first establish a relationship

between the dependent variable and each of the independent variables. The assumption

for multiple regressions consisted of a relationship between each of the independent variables and dependent variable that is linear (Leech et al., 2005). It was important to first check the correlations among the independent variables prior to running the multiple regressions, to determine if the variables were sufficiently correlated. Considering the correlation matrix that was generated, the researcher determined if the variables were highly correlated (0.50 or above) and eliminated them accordingly.

Multiple regression analysis was conducted to examine factors contributing to participants gain in self-efficacies and outcome expectancies. The independent variables included in the multiple regression equations were the participants' science education background, professional position, number of years taught, and teacher qualification status in science. The researcher entered the data into SPSS using the method, Enter, which tells the computer to consider all the variables at the same time. A Model Summary table was then generated to show the multiple correlation coefficient (R), using all the independent variables simultaneously.

Overall Quality of Research Design

Campbell and Stanley (1963) refer to experiments that lack random assignments as quasi-experimental. One of the problems associated with the quasi-experimental design is establishing suitable controls so that any changes in the posttest can be attributed to the treatment and not extraneous variables (variables other than the ones under investigation). Eliminating these extraneous variables increases the degree of accuracy of the study (Gall et al., 2007). By controlling these variables the researcher strengthens the power of the results of the experiment to conclude a true cause – and –

effect relationship. Both internal and external validity of the research design need to be examined to ensure the quality of the design of the study.

Internal Validity

Internal validity as defined by Gall et al. (2007) is "the extent to which extraneous variables have been controlled by the researcher, so that any observed effect can be attributed solely to the treatment variable" (p. 383). In terms of internal validity, the quasi-experimental design is second only to a true experimental design, which has total internal validity (Newman & Newman, 1994).

Cook and Campbell (1979) recommend the quasi-experimental design but also describe four possible threats to internal validity; selection maturation (the reading or interpretation of items on the instrument), instrumentation (not measuring what you intended it to measure), differential statistical regression (only taking one measurement, rather than many and calculating a mean score) and interaction of selection and history (taking into account the participants' backgrounds and what they are bringing in to this program). The main threat to the internal validity of quasi-experiments is the possibility that group differences on the pretests and posttests are due to preexisting group differences rather than to a treatment effect (Gall et al., 2007).

The following procedures were implemented in order to take into account the internal validity for this study. First, every session of the inquiry-based professional development program was completed in the same natural setting with the same implementation, and course materials. Secondly, an assessment plan was implemented over a 15-month time period unlike previous studies that have been completed over

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shorter (4 day to 2 week) time periods. And finally, a valid and reliable instrument, the STEBI-Form A was used to measure the self-efficacy and outcome expectancy of the participants. In addition, the random assignment of participants to the experimental group greatly strengthened the internal validity of the study.

External Validity

External validity is defined by Gall et al. (2007) as "the extent to which the findings of an experiment can be applied to individuals and settings beyond those that were studied" (p. 388). Internal and external validity are rivals to one another. For example, if the study is too pure in internal validity then it will be difficult to generalize the results for a larger population.

External validity could be threatened by the generalization of the findings to the target population. The findings may or may not be generalized for all populations (population validity) because of different environments, settings, cultural, economic, or even gender differences. The Hawthorne effect refers to any situation in which experimental conditions may influence the outcome of results (Gall et al., 2007). In this study, the Hawthorne effect would be present if the participants are aware of participating in an experiment, are aware of the hypothesis, or are receiving special attention as a result of improving their performance. Gall et al. (2007) describe another threat to external validity as the interaction of time of measurement effect. This effect occurs when the administration of two points in time may result in different findings. These factors, not the experimental treatment itself, may cause a change in their behavior. External validity

of the experiment is then jeopardized because the findings might not generalize to a target population.

Professional development providers have attempted to have all grade bands of this program in similar environments and settings to reduce ecological validity. In addition, instructors gave minimal special attention to research participants to reduce any Hawthorne effect that may arise. To reduce the interaction of time of measurement effect, the researcher gave the participants two posttests. The first posttest was given after 8 months of implementation of the program within their classrooms and the second time (follow-up posttest) at the end of the second summer workshop (2008).

Limitations

Gall et al. describe the main threat to the internal validity of a quasi-experimental design is the possibility that group differences on the posttest are due to pre-existing group differences rather than to a treatment effect (Gall et al., 2007). They suggest that analysis of covariance is frequently used to handle this problem because this procedure reduces the effects of initial group differences by making compensating adjustments to the posttest means.

Internal validity threats related to this study include:

1. History – experimental treatments extend over a period of time, providing opportunity for other events to occur besides the experimental treatment such as, each grade band having different instructors who have individual teaching techniques. In addition, during the 8-month implementation period, participants may change self-efficacies and outcome expectancies as a result of interaction with their own students.

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The length of time of 15 months that the teachers are involved in this inquiry-based professional development program suggests that teachers will have changes in their self-efficacy and outcome expectancy of student learning because they will be able to implement information gained with their own students throughout the included school year.

2. Testing – participants might show growth on the posttest if a similar pretest is used simply because the participants became familiar with the instrument, not because of the treatment. Participants completed the STEBI-Form A on three separate occasions; therefore, there might be some familiarity with the instrument for the participants. However, since there are several months between survey completions, participants may also forget exact details of each question on the instrument.

3. Instrumentation – experiments involving observable measurements may see a change after the treatment simply because they consciously or subconsciously expect a change to have occurred. Participants in this inquiry-based professional development program may truly believe their self-efficacy and outcome expectancy for student learning were going to change as a result of this program.

4. Statistical regression – the tendency for research participants whose scores fall at either extreme on a measure to score nearer the mean when the variable is measured a second time. For example, participants' mean score on the second test probably will be higher than the first test with or without an intervening experimental treatment because of statistical regression.

5. Experimental mortality – some participants might be lost from the experimental group because they drop out of the study, miss pretesting or posttesting, or are absent

during some of the sessions. Because this study spans a 15-month time frame, there were

participants that needed to drop out of the program for various reasons, thus unable to

complete the full 120 hours of professional development (Gall et al., 2007). So only

participants who completed all three STEBI-Form A administrations were subjects for

this study.

Summary

This chapter described the process used to conduct a study that evaluates the self-

efficacies and outcome expectancies of inservice science teachers after active

participation in an inquiry-based professional development program. The main questions

of this study, research hypotheses, and the null hypotheses were detailed. The

demographics of the sample were described using data from each participant's survey. In

addition, this chapter reviewed the research variables and the statistical tests that were

used to appropriately respond to the hypotheses.

CHAPTER IV

RESULTS

Introduction

The purpose of this chapter is to report the results of the statistical analyses that

tested the four null hypotheses. The statistical software used for this analysis was SPSS

for Windows 16.0. This chapter contains descriptive statistics of the participants,

explanation and rationale for repeated measure and multiple regression statistical

methods, and results of the statistical tests for each of the four hypotheses.

Null Hypotheses

1. There is no significant overall gain in self-efficacy measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

2. There is no significant overall gain in outcome expectancy of students' learning measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

3. Science education background, professional position, number of years taught, and teacher qualification status are not significant contributing factors to science teachers' self-efficacies.

4. Science education background, professional position, number of years taught, and teacher qualification status are not significant contributing factors to science teachers' outcome expectancies.

In order to examine the data distribution of the variables included in the study to conduct

inferential statistics, descriptive statistics were conducted. Probability of type 1 error was

set at the 0.05 level to reject the null hypothesis, with power of 0.80 and sample size of 64 for repeated measure and multiple regression analysis as was recommended by Cohen (1992). It is worth noting that the sample size to conduct the repeated measure statistical analyses in this study was n = 60 (the number of participants available for all three administrations of the instrument) and for multiple regression n = 73 (the number of participants available to complete the follow-up posttest). Thus, the results will be interpreted with caution.

Descriptive Results

Of the 86 participants who began this inquiry-based professional development program, not all participants completed the entire program. After a review of all three coded STEBI-Form A instruments, it was revealed that all 86 participants completed the pretest, while 67 participants completed the posttest, and 73 participants completed the follow-up posttest. Due to the absence of some participants' post and follow-up posttest, the initial group of 86 was reduced to 60 participants who completed all three STEBI instruments for conducting repeated measure analysis. Using Cohen's sampling table (1992), a sample size of 60 was not a large sample (Cohen's sampling table (1992) suggested n = 64) and therefore, conducted repeated measure, with a type 1 error of 0.05, and power of 0.80.

The purpose of running descriptive statistics is (1) to provide general descriptive information of the variables included in this study, (2) to provide data distribution to satisfy assumptions of conducting inferential statistics, and (3) to examine the relationships between dependent and independent variables. The two dependent

variables in this study were self-efficacy and outcome expectancy. Four independent

variables were also included in this study; science education background, professional

position, number of years taught, and teacher qualification status in science.

Of the 86 teachers who participated in this professional development program,

there were 18 male and 68 female. Typology of school districts segmented the

participants coming from 7 buildings in Rural 1, 6 from Rural 2, 1 from Rural 3, 11 from

Urban 4, 2 from Urban 5, and 2 participants from Urban 6 school districts. For science

education background, almost half of the participants, 40 (46.5%) had completed one

through five college courses. The next largest group came from 27 participants (31.4%)

who completed 6 to 10 college courses. Nine teachers (10.5%) of the participants

completed 26 to 30 college courses while the remaining 10 (11.6%) participants

completed 11 to 25 college courses. For professional position, the majority of the

participants, 71 (82.6%) are practicing classroom science teachers, while the remaining

15 (17.4%) are intervention specialists. The majority of these intervention specialists had

enrolled in the program in order to receive teacher qualification status in science. There

were no participants who described themselves as science resource teachers or

administrators. For number of years taught, the participants displayed a wide range of

experience from their first year teaching to 35 years of experience. The average years of

teaching was 11.47 years, sd = 8.66. The large standard deviation shows the

heterogeneity of the sample. For teacher qualification status in science, of the 86

participants who began the professional development program, 69 (80.2 %) were already

considered highly qualified science teachers. The remaining 17 (19.8 %) of participants

completed this program in order to receive the status of being highly qualified in science

at its completion. Table 4.1 presents participants' science education background, number of years taught, professional position, and teacher qualification status in science.

Table 4.1

Participants' Science Education Background

Variable	N	Percent
Science Education Background		
1-5 College Courses	40	46.5
6-10 College Courses	27	31.4
11-15 College Courses	6	6.9
16-20 College Courses	1	1.2
21-25 College Courses	3	3.5
26-30 College Courses	9	10.5

Table 4.2

Percentage of Participants Professional Position

Variable	N	Percent
Classroom Teacher	71	82.6
Intervention Specialist	15	17.4

Table 4.3

Mean and Standard Deviation for Years of Experience

Years of experience	M	SD	Range
	11.47	8.66	1 - 35

Table 4.4

Percent of Participants Teacher Qualification Status

Highly qualified in science	N	Percent
Yes	69	80.2
No	17	19.8

The participants completed the Science Teaching Efficacy Beliefs Instrument

(Form A) on the first day of the inquiry-based professional development program. The

participants then completed the same instrument after 8 months of incorporating

workshop activities/lessons in their own classrooms with their own students and finally, a

third time upon completion of the program 15 months from the start. The STEBI-Form A

was developed to measure efficacy related specifically to a person's belief in his/her

ability to teach science. From the STEBI-Form A, two distinct subscales were calculated

which reflect personal efficacy and outcome expectancy as they related to science

teaching and students' ability to learn science. The Personal Science Teaching Efficacy

(PSTE) subscale indicated the participants' beliefs about themselves and their ability to

teach science, and the Science Teaching Outcome Expectancy (STOE) subscale indicated the teachers' beliefs about their students' abilities to learn science.

The researcher divided the 25 questions on the STEBI-Form A into the two subscales, PSTE, and STOE. The STEBI-Form A consisted of 13 positively and 12 negatively stated statements. Each question on the subscales was assigned a numerical value based on the statement being a positively written statement (SA = 5, A = 4, U = 3, D = 2, SD = 1) or a negatively written statement (SA = 1, A = 2, U = 3, D = 4, SD = 5). Each participant's subscales were then given a total value for the PSTE and STOE by adding the values for each question. The mean and standard deviation values were then calculated by entering data into the SPSS 16.0 version for Windows. This process was repeated for each of the three administrations of the STEBI-Form A (pretest, posttest, and follow-up posttest). These three scores were the values used in order to conduct repeated measure analysis.

The mean score of the PSTE was 48.38 (sd = 7.32) for the pretest, 50.27 (sd = 5.99) for the posttest, and 51.85 (sd = 5.17) for the follow-up posttest. The maximum score of 65 is possible for the PSTE subscale. The pretest mean score of the STOE was 41.03 (sd = 5.56) out of a maximum score of 60, the posttest was 42.72 (sd = 5.16) and 42.85 (sd = 5.39) for the follow-up posttest. Because most common inferential statistics assume that the dependent variable is normally distributed, it is important to know if variables in the study are highly skewed (Leech et al., 2005). Skewness describes the tail of the curve, or extreme scores at either end. If one tail of a frequency distribution is longer than the other, the curve is skewed (Leech et al., 2005). Leech et al. state if skewness is more than +1.0 or less than -1.0, the distribution is markedly skewed and

may affect statistical analysis. If scores are found within that range, distribution is approximately normal. All skewness values in this study were found to be in acceptable range for statistical analysis. Kurtosis is the quality of distribution such that it is flat or peaked (Leech et al., 2005). Leech et al. state that kurtosis does not appear to affect the results of most statistical analyses. The largest kurtosis value in this study was a +2.318 for the PSTE posttest, indicating a higher than normal peak for those results. Table 4.5 describes the mean score, standard deviation, range, skewness, and kurtosis for each of the three administrations of both subscales, the PSTE and STOE.

Table 4.5

Science Teaching Efficacy Beliefs Instrument Means and Standard Deviations

Variable	Mean	S.D.	Range	Skewness	Kurtosis
Personal Science Teaching Efficacy					
Pretest	48.38	7.32	35	-.519	.277
Posttest	50.27	5.99	33	-1.044	2.318
Follow-up Posttest	51.85	5.17	24	-.052	-.354
Science Teaching Outcome Expectancy					
Pretest	41.03	5.56	26	.398	-.205
Posttest	42.72	5.16	26	-.221	.038
Follow-up Posttest	42.85	5.39	26	-.133	-.016

Repeated Measure Analysis

This section presents the results of testing the following two null hypotheses. The hypotheses tested were: (1) gains in self-efficacy, and (2) gains in outcome expectancy.

Null Hypothesis 1: There is no significant overall gain in self-efficacies as measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

Repeated measure analysis was conducted to determine if there was a gain from beginning to end of the professional development program. The dependent variable was composite scores of self-efficacy (PSTE). The independent variable was time. The test result indicated that null hypothesis was rejected in favor of the research hypothesis and that there was a significant overall gain in self-efficacies from pretest to posttest and to the follow-up posttest. The participants' mean score went from M = 48.38 on the pretest to M = 50.27 on the posttest and finally M = 51.85 on the follow-up posttest which accounted for a total mean gain of 3.47. The largest change occurred between the pretest and posttest with a mean gain of 1.89. The mean gain between posttest and follow-up posttest was 1.58. The results of this test indicated that the gain in self-efficacy was statistically significant ($p \leq .000$). The trend in growth is linear ($p \leq 0.00$). Table 4.6 and Figure 1 present the repeated measure result and the trend across the three time points.

Table 4.6

PSTE Means, Standard Deviations, and Significance

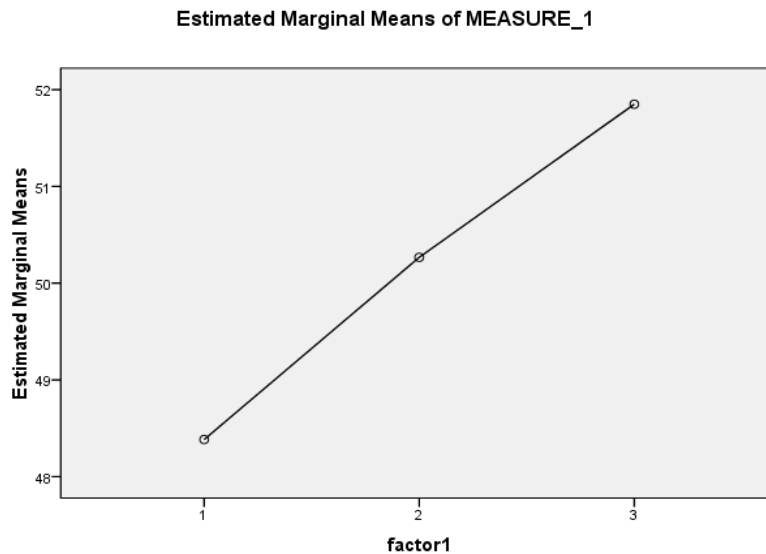| Variable	Mean	Standard deviation	Sig.
Pretest	48.38	7.32	.000
Posttest	50.27	5.99	.000
Follow-up Posttest	51.85	5.17	.000

Figure 4.1. Mean scores for PSTE: Pretest, posttest, and follow-up posttest.

Effect size is a measure of how different two groups are from one another, or a measure

of the magnitude of the treatment (Salkind, 2004). The effect size calculation, in addition

to significance, gives the reader an interpretation of the difference that is really seen after

the treatment. The effect size was calculated for degree of change to be $d = 0.32$ between

the pretest and posttest. This value, according to Salkind (2004) translates into the

standard z- score, 12.55% area beneath the normal curve. Z-scores are the standardized

score that describes the intervention effect of the treatment. In this study, the treatment is

the inquiry-based professional development program. It is important to convert raw

scores to standardized scores (z-score) so they can be directly comparable to one another

in terms of relative location in the distribution of the normal curve. Scores that fall below

the mean have negative z-scores, and those above the mean have positive z-scores

(Salkind, 2004). All z-scores calculated in this study were found to be positive values,

therefore, always falling to the right of the mean indicating a gain in the upper half of the

distribution of the curve. The effect size between posttest and follow-up posttest was calculated and also found to be $d = 0.26$ or 10.26% area beneath the normal curve. The total growth from the beginning of the professional development program to the end was 22.81%. These values, according to Cohen, are categorized as medium effect sizes, meaning there is a moderate overlap of the two groups (pretest to posttest and posttest to follow-up posttest).

> Null Hypothesis 2: There is no significant overall gain in outcome expectancy of students' learning measured by the STEBI-Form A for science teachers after participating in an inquiry-based professional development program.

Repeated measure analysis was conducted to determine if there was a gain from beginning to end of the professional development program. The dependent variable was composite scores of outcome expectancies (STOE). The independent variable was time. The test result indicated that the null hypothesis was accepted in favor of the research hypothesis and that there was not a significant overall gain in self-efficacies from pretest to posttest and to the follow-up posttest. The results of testing Hypothesis 2 are found in Table 4.7 and Figure 2. The average mean gain in outcome-expectancies did not account for a significant amount of change in pretest, posttest, and follow-up posttest. The participants' mean score went from $M = 41.03$ on the pretest to $M = 42.72$ on the posttest and finally $M = 42.85$ on the follow-up posttest which accounted for a total mean gain of 1.82. The largest change occurred between the pretest and posttest with a mean gain of 1.69. The mean gain between posttest and follow-up posttest was 0.13. The results of this test indicated that the gain in outcome expectancy was not statistically significant ($p = 0.085$). The trend in growth was quadratic ($p = 0.103$). The effect size between pretest and posttest was calculated for degree of change to be $d = 0.30$ (z-score of 11.79 % area

beneath the normal curve), thus indicating a medium effect size while the effect size

between posttest and follow-up posttest was $d = 0.03$ (z-score of 1.20% area beneath the

normal curve), a small effect size (Salkind, 2004). The total positive growth for STOE

subscale from the beginning of the professional development program until the end was

12.99%.

Table 4.7

STOE Means, Standard Deviations, and Significance

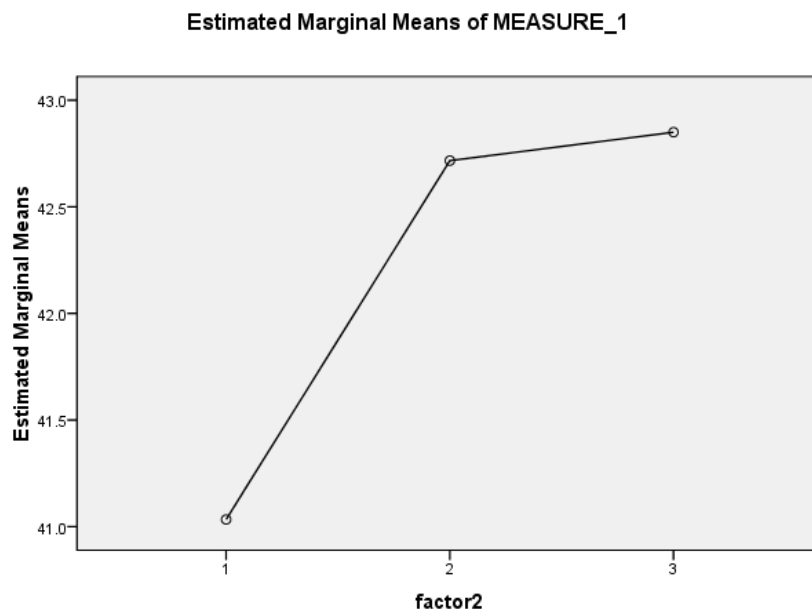| Variable	Mean	Standard deviation	Sig.
Pretest	41.03	5.56	.085
Posttest	42.72	5.16	.085
Follow-up Posttest	42.85	5.39	.085

Figure 4.2. Mean scores for STOE: Pretest, posttest, and follow-up posttest

Results of Multiple Regression

The researcher chose multiple regressions for hypotheses three and four to
examine correlations between the results of the STEBI-Form A (PSTE and STOE
subscales) and their relationship with the variables under investigation: number of years
taught, teacher qualification status in science, professional position, and science
education background. Furthermore, the researcher examined the results of
interrelationships between the dependent variables (follow-up posttest scores of PSTE
and STOE) and independent variables (number of years taught, teacher qualification
status in science, professional position, and science education background) to test for
significant predictors regarding inservice teachers' self-efficacy and outcome expectancy
about teaching science. The score used for PSTE and STOE subscales dependent
variable was the follow-up posttest score. The researcher chose this composite score to
use as the criterion variable in multiple regression because it was the largest of three
administrations of the STEBI-Form A and thought to be a better variable for comparison
with the independent variables. The number of participants taking this final
administration of the STEBI-Form A was n = 73.

According to Mertler and Vannatta (2004), there are three assumptions about raw
scale variables in multiple regression. The first assumption is that the independent
variables are fixed, meaning the same values if the independent variables would have to
be used if the study was replicated. The second assumption is that the independent
variables are measured without error. The last assumption states the relationship between
independent variables and dependent variables is linear (Mertler & Vannatta, 2004). This
linear relationship indicates that the independent variables directly predict the outcome of

the dependent variables. Mertler and Vannatta describe pre-analysis screening to test for

the linearity assumption. Therefore, before multiple regressions were tested for

hypotheses three and four, the researcher calculated a Pearson's coefficient (two-tailed)

to first examine if there was a linear relationship between the dependent variable and

each of the independent variables. A correlation matrix was generated to identify any

variables that were highly correlated. The PSTE follow-up posttest scores were found to

have a correlation between the number of science courses completed, $r = .364$; the

professional position held, $r = 0.311$; and the teacher qualification status in science, $r =$

-0.398. The negative value for teacher qualification status (HQT) resulted from the

coding of the number of participants that currently held the HQT status to those

participants that did not. Those participants that already had the HQT status were coded

as 1, while the non-HQT participants were given the code of 2. Since there were higher

numbers of non-HQT versus HQT participants, the correlation value was negative. The

coefficient of determination, r2 was found to be; r2 = 0.132 for number of science

courses completed; r2 = 0.097 for professional position; and r2 = 0.158 for teacher

qualification status. These values correspond to having a 13.2%, 9.7%, and 15.8%

respectively of the variance in the PSTE subscale. The STOE follow-up posttest scores

were found to have a correlation between teacher qualification status in science and

professional position at the 0.01 level, $r = -0.398$. The coefficient of determination was

r2 = 0.204 indicating only 20.4% of the variance. Tables 4.8 and 4.9 present the

interrelationships between the follow-up posttests of the PSTE and STOE subscales with

the independent variables: number of years taught, teacher qualification status in science,

professional position, and science education background.

Table 4.8

PSTE Correlations

	PPost	Course	Position	Year	HQT
PPost Pearson	1	**.364****	**.304***	.217	-.223
Sig. (2-tailed)		.004	.018	.095	.086
Course Pearson		1	.072	-.039	.006
Sig. (2-tailed)			.582	.766	.962
Pos Pearson			1	.059	**-.340****
Sig. (2-tailed)				.655	.008
Year Pearson				1	-.124
Sig. (2-tailed)					.346
HQT Pearson					1
Sig. (2-tailed)					

Note. ** Correlation is significant at the 0.01 level (2-tailed).
       * Correlation is significant at the 0.05 level (2-tailed).

Table 4.9

STOE Correlations

	Course	Position	Year	HQT	SPost
Course Pearson	1	.072	-.039	.006	-.039
Sig. (2-tailed)		.582	.766	.962	.770
Pos Pearson		1	.059	**-.340****	.127
Sig. (2-tailed)			.655	.008	.335
Year Pearson			1	-.124	.184
Sig. (2-tailed)				.346	.159
HQT Pearson				1	.131
Sig. (2-tailed)					.317
SPost Pearson					1
Sig. (2-tailed)					

Note. ** Correlation is significant at the 0.01 level (2-tailed).

Null Hypothesis 3: Science education background, professional position, number of years taught, and teacher qualification status are significant contributing factors to science teachers' self-efficacies.

The dependent variable was first entered into SPSS multiple regression equation. The independent variables were then entered by the Enter Method, that is, simultaneously entering them into the analysis. Each independent variable was then evaluated in terms of what it added to the prediction of the dependent variable (Mertler & Vannatta, 2004).

Standard multiple regression was conducted to determine the accuracy of the independent variables: science education background (course); professional position (pos); number of years taught (Year); and teacher qualification status (HQT) predicting PSTE scores. Regression results indicate that the overall model significantly predicts science education background, R2 = 0.254, R2adj = 0.210, F (4, 68) = 5.784, p <.05. This model accounts for 25% of variance in science education background. The overall significance of the model was p = 0.001. These results are presented in Table 4.10. A summary of regression coefficients is presented in Table 4.11 and indicates that while the overall model is significant, only one (science education background) of the four variables significantly contributed to the model.

Table 4.10

PSTE Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig.
1	.504	.254	.210	5.037	.001

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The results of testing Research Hypothesis 3 are found in Table 4.10. The relationship between self-efficacies and science education background was found to be significant ($p = 0.002$). The relationships between self-efficacies and professional position ($p = 0.073$), number of years taught ($p = 0.086$), and teacher qualification status ($p = 0.385$) in science were not found to be significant. The unstandarized regression coefficient (B), represents the slope weight for each variable in the model and was used to create the regression equation. B also indicated how much the value of the dependent variable changed when the independent variable increased. A positive B specifies a positive change in the dependent variable when the independent variable increases, whereas a negative B indicates a negative change in the dependent variable when the independent variable increases. Standardized regression coefficients, β, are utilized to create a prediction equation for the standardized variables. Therefore, the researcher accepted Research Hypothesis 3 in terms of the participants' science education background having a relationship with their self-efficacies. The researcher rejected the relationship between self-efficacies and professional position, number of years taught, and teacher qualification status in science.

Table 4.11

Coefficients for Model Variables PSTE

	B	β	t	P
Course	.232	.348	3.303	.002
Pos	3.088	.210	1.819	.073
Year	.115	.185	1.742	.086
HQT	-1.309	-0.10	-0.874	.385

Null Hypothesis 4: Science education background, professional position, number of years taught, and teacher qualification status are significant contributing factors to science teachers' outcome expectancies.

Standard multiple regression was again conducted to determine the accuracy of the independent variables (science education background [course]; professional position [pos]; number of years taught [Year]; and teacher qualification status [HQT]) predicting STOE scores. Regression results indicate that the overall model significantly predicts science education background, $R2 = 0.095$, $R2adj = 0.031$, $F (4, 68) = 1.579$, $p < .05$. This model accounts for 8.5% of variance. The overall model was found to not be significant, $p = 0.190$. Table 4.11 presents the statistics for the overall model. A Summary of regression coefficients is presented in Table 4.12 and indicates that none of the four variables significantly contributed to the model.

The results of testing Hypothesis 4 are found in Table 4.12. The relationship between outcome expectancies and science education background ($p = 0.866$), professional position ($p = 0.064$), number of years taught ($p = 0.186$), and teacher qualification status in science ($p = 0.135$) was not found to be significant. Therefore, the researcher rejected Research Hypothesis 4.

Table 4.12

STOE Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig.
1	.292	.085	.031	5.148	.190

Table 4.13

Coefficients for Model Variables STOE

	B	*β*	*t*	*p*
Course	-.012	-.020	-0.170	.866
Pos	3.270	.241	1.885	.064
Year	.090	.157	1.335	.186
HQT	2.316	.192	1.513	.135

Summary

In Chapter IV descriptive variables and the results of testing general research hypotheses were reported. Although the participants showed a significant gain in self-efficacies from the beginning of the professional development program to the end of the program, there was a significant growth from pretest to posttest in their outcome-expectancies for student learning, but a quadratic growth trend from the posttest to the follow-up posttest. A significant relationship was found between the participants' self-efficacies and their science education background, but no significant relationship was recorded regarding outcome-expectancies with professional position, number of years taught, nor teacher qualification status in science. There was no significant relationship found between outcome expectancies of participants science education background, professional position, number of years taught, nor teacher qualification status in science. The interpretation and implications to guide professional development programs will be discussed in Chapter V in detail.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Chapter V is divided into four main sections. The first section, the summary, states the problem, summarizes procedures followed in the study, and reviews the research hypotheses tested. Section two includes each general research hypothesis, the major findings for each hypothesis, and finally discusses the conclusions. Section three, implications of the study, discusses the significance of the research findings, and the final section offers suggestions for future research.

Statement of the Problem

This study investigated overall change in science teachers' self-efficacies and outcome expectancies as measured by the Science Teaching Efficacy Belief Instrument (STEBI-Form A), from the two subscales Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE), as a result of teachers' participation in an inquiry-based professional development program. Demographic variables such as science education background, professional position, number of years taught, and teacher qualification status in science were used in predicting self-efficacy and outcome expectancy gains. Difference scores on the STEBI-Form A were based on three intervals: (a) pre to post, (b) post to follow-up post, and (c) pre to follow-up post.

The participants (N = 60), were practicing teachers in Midwestern school districts who chose to participate in an inquiry-based professional development program. The teachers were expected to make a 15-month commitment which began in the summer of 2007 with a 2-week long session, followed by 8 months of classroom implementation of lessons experienced which continued throughout the following school year, ending in the summer of 2008 with an additional week of training.

Statement of the Procedures

A quasi-experimental design was used to investigate the changes in self-efficacies and outcome expectancies scores and the possible relationship with science education background, professional position, number of years taught, and teacher qualification status in science. The data consisted of three sets of PSTE scores: pretest, posttest, and a follow-up posttest and three sets of STOE scores: pretest, posttest, and a follow-up posttest. Four variables were included in this study: science education background, professional position, number of years taught, and teacher qualification status in science. The treatment was the inquiry-based professional development program.

Riggs and Enochs (1990) constructed the instrument used for identifying the level of science teaching efficacy and outcome expectancy in school teachers. The instrument, the Science Teaching Efficacy Belief Instrument, STEBI-Form A (inservice form), consists of 25 Likert items investigating the two dimensions of self-efficacy – Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). The researcher developed the Demographic Survey.

The teachers in this professional development program met for 2 weeks in the summer of 2007 for all day sessions. The participants completed the STEBI-Form A and the Demographic Survey on the first day of the program. Throughout the following school year the participants were expected to implement with their own students the activities they experienced in the professional development program. The participants returned to the professional development program site in April of 2008 for one more session at which time they completed the STEBI-Form A for a second time (posttest). In the summer of 2008, the teachers returned for a final week of professional development sessions. At the final session the participants completed the STEBI-Form A for the last time (follow-up posttest).

Repeated measures were used to test the significance of gains in self-efficacies and outcome expectancies from pretest to posttest, posttest to follow-up posttest, and pretest to follow-up posttest. Multiple regression models were used to test the relationship between (a) self-efficacies and science education background, professional position, number of years taught, and teacher qualification status in science, and (b) outcome expectancies and science education background, professional position, number of years taught, and teacher qualification status in science.

The researcher established an alpha level of 0.05 as the standard for significance estimated by the repeated measure and multiple regression tests. With an N of 60 for repeated measure analysis and N of 73 for multiple regression analysis and a medium effect size, power was estimated to be 0.80.

Research Hypotheses

The following research hypotheses were generated to examine the relationship

between a change in self-efficacies and outcome expectancies of science teaching.

Science education background, professional position, number of years taught, and teacher

qualification status in science were used in predicting a relationship to participants' self-

efficacies and outcome expectancies of science teaching with these participants.

> Research Hypothesis 1. There is a significant overall gain in self-efficacies
> measured by the STEBI-Form A for science teachers after participating in an
> inquiry-based professional development program.
>
> Research Hypothesis 2. There is a significant overall gain in outcome
> expectancies of students' learning measured by the STEBI-Form A for science
> teachers after participating in an inquiry-based professional development
> program.
>
> Research Hypothesis 3. Science education background, professional position,
> number of years taught, and teacher qualification status are significant
> contributing factors to science teachers' self- efficacies.
>
> Research Hypothesis 4. Science education background, professional position,
> number of years taught, and teacher qualification status are significant
> contributing factors to science teachers' outcome expectancies.

Findings From Hypotheses 1 and 2

Specific research hypotheses 1 and 2 dealt with the hypothesized relationship

between the average gain in science teachers' self-efficacies and outcome expectancies

after participation in a 15-month, inquiry-based professional development program. For

research hypothesis 1, the average gain in self-efficacies did account for a significant

change when predicting gains in Personal Science Teaching Self-Efficacy: pretest to

posttest (M gain = 1.89; sd = 7.32), and from posttest to follow-up posttest (M gain =

1.58; sd = 5.99). The results of this test indicated that the gain was statistically

significant at the $p < 0.05$ level. The Z-score which describes the intervention treatment was found to be 22.81%.

For research hypothesis 2, the average gain in outcome expectancies did not account for a significant change when predicting gains in Science Teaching Outcome Expectancy: pretest to posttest (M gain = 1.69; sd = 5.56), and from posttest to follow-up posttest (M gain = 0.13; sd = 5.16). The results of this test indicated that the gain was not statistically significant at the $p < 0.05$ level. The total Z-score for hypothesis 2 was found to be 12.99%.

The purpose of this study investigated science teachers' self-efficacies and outcome expectancies. Results indicated science teachers' self-efficacies did significantly increase over time as a result of their participation in the inquiry-based professional development program; however, their outcome expectancies did not.

In congruence with Riggs' study, teachers who began with low PSTE (48 out of a possible 60) and STOE (41 out of a possible 55) made gains in self-efficacies but remained nearly constant in outcome expectancy scores (Riggs, 1995). These findings support the work of Roberts, Henson, Tharp, and Moreno who also found that inservice activities had the greatest impact on the efficacies of teachers who began their program with the lowest self-efficacies (Roberts et al., 2001). Similarly in Posanski's research, 43 elementary inservice science teachers exhibited a significant PSTE gain score from pretest to posttest, while their STOE score was not significantly affected (Posnanski, 2002). In contrast, Crowther and Cannon's study concluded after a professional development inservice program for science teachers where the STEBI was administered three times; pretest, post-workshop, and 5 months after the conclusion of the workshop

that there was no statistically significant change in self-efficacies; however, there were

significant increases in the outcome expectancies between the post-workshop and the

final assessment (Crowther & Cannon, 2000).

This study reports that while there was a rise in outcome expectancy, it was not as

large as the rise in teacher self-efficacy. These results coincide with Lumpe et al.'s

(2000) study which also found a larger gain in science teachers' self-efficacy than their

outcome expectancy. Lumpe et al. suggest the smaller increase in outcome expectancy

may be due to other environmental characteristics, such as support from administrators,

availability of a common planning period, reduced class size, resources, and additional

funding (Lumpe et al., 2000).

<center>Findings From Hypotheses 3 and 4</center>

Hypotheses 3 and 4 investigated the relationships between self-efficacies and

outcome expectancies with the independent variables: science education background,

professional position, number of years taught, and teacher qualification status in science.

The third hypothesis was partially supported. There was a relationship between science

teachers' self-efficacies and science education background (number of college science

courses completed). The relationship between self-efficacies and science education

background was found to be significant ($p = 0.003$), R2 = 0.270 and F = 5.083, at $p <$

0.05. Science education background accounted for 27% of unique variance in predicting

Personal Science Teaching Efficacy. Teachers' self-efficacies were not predicted by

professional position, number of years taught or teacher qualification status in science.

These variables did not account for a significant amount of unique variance in predicting

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gains in Personal Science Teaching Efficacy; professional position ($p = 0.074$), number of years taught ($p = 0.087$), and teacher qualification status ($p = 0.317$), at $p \leq .05$, and therefore were not found to be significant contributors. These results support the work completed by Ramey-Gassert, Shroyer, and Staver (1996) who also found that there is a statistically significant relationship between the science education background of science teachers and their self-efficacy beliefs regarding science teaching (Ramey-Gassert et al., 1996). This study's results complied with other studies that have concluded that an increase in strong science content relates to higher levels of science teaching self-efficacy beliefs (Borko & Putman, 1995; Butts, 1988; Oliver, 1995; Riggs, 1995; Shrigley, 1977; Shrigley & Johnson, 1974).

In the research findings reviewed for this study the number of years teaching was not used as a direct variable in predicting self-efficacy but was used in conjunction with self-efficacy in predicting reform implementation in the classroom. In the study conducted by Czerniak and Lumpe (1995), self-efficacy was the only strong variance in determining reform implementation. Therefore, the number of years teaching did not contribute as a predicting factor. Similarly, the results of this study also found that the number of years teaching did not have an impact on teachers' self-efficacies or outcome expectancies with regard to science teaching.

The fourth hypothesis was not supported by any of the independent variables. There was not a statistically significant relationship found between science teachers' outcome expectancies and science education background (number of college science courses completed), professional position, number of years taught, nor teacher qualification status in science. The relationship between outcome expectancies and each

of the following variables was found to be not statistically significant: science education

background ($p = 0.721$), professional position ($p = 0.163$), number of years taught ($p =$

0.131), and teacher qualification status ($p = 0.112$) at $p < 0.05$. Science education

background accounted for the most unique variance in predicting Science Teaching

Outcome Expectancy score at 9.2%. These variables did not account for a significant

amount of unique variance in predicting gains in science teaching outcome expectancy

and therefore were not found to be significant contributors.

The results substantiated the belief of many researchers that simply holding

beliefs about the benefits of inquiry-based practices is not sufficient to implementing

them into the classroom (Brown & Melear, 2006). Unlike the other studies reviewed, this

study was conducted over a 15-month time period where the participants experienced

inquiry-based lessons led by the professional development providers, had 8 months of

classroom implementation with their own students, and came back for a second summer

session for more training. This unique aspect of time in which the participants were

putting into practice the lessons they learned may account for the increase in teachers'

personal science teaching efficacy. As reported by Guskey (1985) and Bolster (1983), it

is the practicing of new ideas that often precedes changes in beliefs regarding those new

ideas. In addition, Peterson et al. (1989) have linked practicing implementation of new

ideas to classroom action in changing behaviors. In Marion's study, she explained that

the self-efficacy and outcome expectancy mean gains may have been higher after the

professional development training, if more time had been taken between the last day of

the summer session and the 6-month span where the posttest was collected (Marion,

1998). Marion concluded teachers needed more time to change beliefs. Marion's finding

agrees with Supovitz and Turner (2000) who found in their research that at least 80 hours of professional development are needed before a statistically significant relationship can be identified between professional development experiences and changes in teaching practice.

One of the major explanations of gains in self-efficacy but not in outcome expectancy of the participants is their widely varied backgrounds. The participants in this study were a heterogeneous group that varied in age, gender, years of science teaching, professional positions (classroom teacher, special education teacher), grade levels (3-10), and different districts. Consequently, the participants held different initial self-efficacies and outcome expectancies in the beginning of the program and the total group gained a differing degree of self-efficacies and outcome expectancies by the conclusion of the program. One possible explanation of this lower change in outcome expectancies measured could be attributed to the participants having widely varied backgrounds and classroom experiences.

The large total growth in self-efficacies of the participants from the beginning of the program to the end of the program (22.81%) could also be an indication that with time for classroom implementation and further training, they feel more confident in their own teaching skills and content knowledge, thus their self-efficacy beliefs increased. In addition, since there was only one independent variable, science education background (number of college science courses completed) that was found to have an impact on self-efficacies, it would appear that increasing science teachers content knowledge (a key goal of the program) would be the largest contributing factor in increasing self-efficacies.

Consequently, adding more science content to professional development programs, over time, should increase teachers' self-efficacies regarding science teaching and learning.

Implications

This study investigated the possible relationship between science teachers' self-efficacies and outcome expectancies (self-efficacy beliefs) over time as a result of participation in a 15-month professional development program. Three beliefs have driven this study: (a) self-efficacy is predictive of behavior (Bandura, 1997), (b) length of time for professional development training determines significant changes in teaching practice (Supovitz & Turner, 2000), and (c) science self-efficacies and outcome expectancies are related to science education background (Ramey-Gassert et al., 1996), professional position, number of years teaching (Czneriak & Lumpe, 1995), and teacher qualification status in science.

The results of this study should be of interest to teachers and supervisors who provide prolonged professional development proposing to affect changes in self-efficacies that include classroom implementation between training sessions. The findings of this study carry implications for those professional development providers charged with the creation and implementation of quality, long-term inquiry-based professional development science education programs.

Implications for Number of Science Courses and Science Content Knowledge

The largest contributor to significantly increasing the participants' self-efficacy in this study was the number of college courses they completed prior to this professional development program. Bleicher (2006) explained that integrating content knowledge

with hands-on learning experiences is the most productive method to increase teachers'

self-efficacy about their abilities to teach science. Many other researchers agree that

having a strong science content background relates to higher levels of science teaching

self-efficacy beliefs (Borko & Putman, 1995; Butts, 1988; Riggs, 1995). Posnanski

(2002) stated it is strong science content knowledge, in association with successful

teaching methods that promotes effective science teaching. He also suggested that it is

the combination of science content knowledge and the number of science courses

completed that play an important role in science teachers' self-efficacy beliefs

(Posnanski, 2002). This research suggests designating time, money, and resources to

professional development programs may be less important than allocating funds to

teachers for taking additional college science courses. Professional development courses

should be layered on top of a firm base of knowledge derived from college content

courses in order to most effectively increase science teachers' self-efficacy beliefs.

This researcher understands that simply recommending teachers to complete more

courses could possibly be problematic. What content courses should they be required to

take? Are these courses similarly taught at all universities? Should these courses be

exclusively for teachers, for non-majors, or for majors? Should these courses be survey,

lecture, or involve laboratory experiences? Is there a specific grade in the course needed

to ensure success? Simply taking more courses does not ensure teachers will gain the

content knowledge needed to become successful science teachers.

Implications for Long-Term Professional Development

One of the major implications of this study is the need for more long-term professional development programs that allow teachers to have the time to identify and potentially change both their self-efficacy beliefs and therefore, teaching behaviors. Previously, most science professional development training programs have varied anywhere from a 2-day workshop to a year long program resulting in minimal change in self-efficacies. Because there was a continued rise in self-efficacies and outcome expectancies over the three administrations of testing, this study supports the notion that long-term professional development programs, where the teachers are active participants, are instrumental in changing science teachers' beliefs. From their research, Johnson, Kahle, and Fargo (2007b) explain that because many professional development opportunities are not sustained for long lengths of time, making changes in self-efficacy beliefs is difficult. This study implies that there is a strong need for long-term professional development programs that provide science teachers with the time essential to learn science content, practice effective teaching methods, and change science teaching self-efficacy beliefs.

Implication for Period of Implementation

The findings of this study suggest that it is not just the length of the professional development program that is crucial, but also the need for an implementation period where teachers can practice what was learned in the training with their own students. In agreement with this idea, Bandura (1977a) advocated strategies such as modeling, verbal persuasion, and successful experiences in the improvement of efficacy beliefs. Many

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researchers have stated that it is the practicing of new ideas and experiences, specifically with inquiry-based science methods that is the precursor to changing science teachers' self-efficacy beliefs (Bolster, 1983; Brown & Melear, 2006; Guskey, 1985). Peterson et al. (1989) take this idea one step further when they suggest that it is beliefs along with practice that links to change in classroom action. One of Marion's (1998) findings concurs that, had there been more time for the participants to implement and practice the information gained in the professional development program, there may have been a larger gain seen in the teachers' self-efficacy beliefs.

Implication for Science Teacher Support

In order to help facilitate change in teachers' self-efficacies it would have been helpful in this study if teachers could have come from schools in teams, thereby having school support in their home schools. Ramey-Gassert et al. (1996) concluded that the main reason there was an influential change in PSTE scores was due to the teachers having support from colleagues once they returned to their own classrooms. Posnanski (2002) also stated self-efficacy scores increased because teams of teachers (2-4 per building) allowed for discussions among peers regarding successes and failures. Support from colleagues would help participants understand new strategies through practice and possibly increase self-efficacies. In this study, the participants self selected to join the professional development program. Perhaps if there were better support from the principals and supervisors encouraging all science teachers in a district to participate in this type of inquiry-based professional development program, the teachers would have a

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greater support system to implement the new strategies when placed back in their own classrooms.

A final implication is that teachers with low outcome expectancy for student learning, as in this study, need additional training aimed at teacher expectations and those expectancies related to student achievement while teachers with low self-efficacy might need more training in science teaching skills and personal belief about those skills.

Weaknesses of the Treatment

While there were numerous common threads taught to all grade band participants, for example, inquiry-based activities in lessons aligned to the science content standards, there was one major difference. There was no consistency in how the workshop content was presented. In many cases, there was one university faculty member and one elementary school teacher who conducted each session. For teachers of grades 3/4, 5 and 6 the activities were taught in an order that best suited the instructors; for example, in the grade 5 group there was a university physics instructor paired with a veteran fifth grade teacher. The physics professor would begin the day by presenting the activities of light, sound, and waves, then the fifth grade teacher would facilitate lessons regarding Life or Earth and Space. The other grade bands were able to stick to one topic per day; for example, the grade 9/10 group discussed plate tectonics one day, physics and motion a second day, while a third day was devoted to all life science activities. All activities in the professional development program were presented as single activities in the professional development program as opposed to themed units, thus jumping from one content standard to another all in one day. Perhaps if investigated in homogeneous

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content units, participants would feel more competent in their science knowledge and implementation of lessons in their own classrooms.

The professional development providers and some instructors were college science faculty (scientists), with little formal science education background. There were no instructors or any persons with curriculum development expertise that were from the college of education (science educators) to connect educational theory to professional development structure during summer sessions or during follow-up meetings. Perhaps if science educators had been involved in the curriculum planning of this professional development program, there could have been days in the follow-up sessions when discussions about how the implementation process occurred in the participants' own classrooms. Participants could have reflected on their own experiences after implementation and shared their insights with the peer participants during follow-up sessions.

In addition to taking the self-reported STEBI-Form A three times, journal writing, reflections, analysis of samples of student work, classroom coaching and evaluating, and interviews with teachers would have been helpful in understanding why participants' outcome expectancies did not increase significantly. To facilitate change in participants, self-efficacy beliefs, professional development instructors could make home school visits to observe participants teaching in order to give support and constructive critiques.

Another weakness of the treatment was the fact that there were so many different instructors for each of the five grade bands. There were different instructors from the cooperating university, as well as different classroom science teachers that served as assisting facilitators for each session. In addition, there were multiple instructors each

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time the sessions met (first summer, second summer, and follow-up meetings) based on the content topics that were to be covered in that session. Each instructor, while covering similar content material, had his or her own unique delivery of material, thus impacting participants' success to a varying degree.

Finally, an additional weakness of the treatment was the irregular attendance of many participants. In the first summer session very few participants missed days; however, the spring follow-up session was poorly attended. Since the STEBI-Form A was given on that day in spring, the numbers were lower than anticipated (from 86 to 67), thus affecting data collection and analysis.

<p style="text-align:center">Suggestions for Further Research</p>

Additional research is warranted to better understand change in science teachers' self-efficacies and outcome expectancies as a result of long-term inquiry-based professional development programs. More research is needed regarding factors that inhibit the increase of science teachers' self-efficacy and outcome expectancy. Is one contributor the lack of confidence of the teachers when implementing inquiry-based lessons? Could another contributor be the district school setting, funds, or resources available? Or are there other factors that preclude teachers from changing their self-efficacy beliefs?

According to Bandura's (1997a) explanation of self-efficacy beliefs being composed of two components, people's expectations regarding certain behaviors to produce desirable outcomes (outcome expectancy), and people's beliefs in their own ability to perform behaviors (self-efficacy); these two constructs are the key components

when developing professional development programs (Bandura, 1997a). Bandura explains it is through experiencing successes that people can gain self-efficacy. This gain can also be accomplished by providing models and social persuasion by strengthening people's beliefs that they possess the characteristics to succeed (Bandura, 1997a). As Pajares (1992) has explained, it is the beliefs that teachers hold about teaching and learning that have a significant influence on teachers' behaviors in the classroom, for example, their teaching strategies. Lumpe et al. (2000) also confirmed it is teachers' beliefs that are the strongest predictors for change. Because of the work these researchers have completed, in addition to the results of this study, the following are some suggestions for future research.

Additional longitudinal studies need to be conducted regarding beliefs and practices. For example, collecting data on the same participant sample over a 5-year period in order to get a better picture of determining change in teachers' beliefs. This extended study would give better understanding of participants changing beliefs over time.

Since outcome expectancy is less often significantly influenced through professional development programs (Khoury-Bowers & Simonis, 2004), researchers might investigate a variety of ways to support teachers by using inquiry methods to increase self-efficacy and outcome expectancy. For example, researchers might look at the role of building principals as a key component in the follow-up phases of professional development programs in order to have an impact on teachers' outcome expectancies. If principals are invited to attend several days of the program so expectations would be known to everyone, they could then possibly influence the participants' experience in the

program. Principals could provide teachers with feedback related to teacher behavior and student achievement during classroom observations and evaluations. In this study, the participants were not coached or evaluated in the classroom implementation portion of the program and received no feedback pertaining to their implementation of inquiry-based lessons. The role of the principal could be the link between the self-reported changes of the participants on the STEBI-Form A and actual changes in teaching strategies that precipitated change in self-efficacy and outcome expectancy.

Future Research Related to Outcome Expectancy

Previous research findings state that the implementation of new inquiry methods may take precedence over the capacity of teachers to focus on student learning (Posnanski, 2002). Posnanski also declares that it is possible that outcome expectancies are more stable and not as easily influenced as self-efficacy beliefs. However, professional development programs that focus on student assessment and achievement could begin to eliminate this lack of change in outcome expectancy. In examining increasing outcome expectancy of teachers and their belief that students will be successful, professional development providers could better utilize the sessions that follow classroom implementation by having purposeful discussions regarding strategies to improve students' attitudes and ability to do inquiry, to critically evaluate examples of student work, and to impact students' achievement and motivation to learn. A second summer session could be a time for critical review of the period of implementation with stories of successes, challenges, and the sharing of information between peers.

Future Research Related to Self-Efficacy

In future research, there needs to be a component of the professional development programs that includes participants' reflection and feedback in order to help alter their self-efficacy beliefs and teaching behaviors. This feedback would help build participants' confidence in engaging in more inquiry-based activities, which might then increase their self-efficacies. Since this study did not attempt to collaborate with participants after their exposure to the program, future analysis of follow-up sessions, which could include discussions of successes or failures in the classroom after implementation, would be helpful in learning about changes in self-efficacy beliefs.

Future research should also include looking at PSTE/STOE responses with the variable of educational background of the participants. For example, did the participants hold BA degrees, BS degrees, Masters in Education, or Masters in a specific content area and how do these differences affect their self-efficacy beliefs. In what areas of science discipline were participants' degrees held (for example, physics, chemistry, and biology)? Since number of courses completed was the statistically significant contributor in this study, remaining questions might be the following: Were the courses completed in a degreed program? How long ago did participants complete these courses?

Other variables that were collected in this study but not used in data analysis might render the following questions: Are there any differences in gender for teaching science? Does it make a difference from what school district topology the participants come from (urban, rural)?

This researcher would also suggest future studies utilizing a different instrument measuring self-efficacies and outcome expectancies on this population to look for

similarities and differences in results. For example, Ritter et al. (2001) developed the

Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) to

assess teachers' self-efficacy and outcome expectancy beliefs with regard to science

teaching and learning in an equitable manner when working with diverse learners, such as

various socioeconomic backgrounds, gender differences, cultural differences and children

who speak English as a second language. Since many of the participating teachers came

from culturally diverse urban districts, the data gained from using this instrument could

be informative when compared to STEBI-Form A.

Future studies that involve tracking individual teachers throughout long-term

professional development programs would be another area of study that should be

considered. Perhaps a case study could be completed, where a number of teachers are

followed for several years to measure their possible self-efficacy change over time. In

addition, separating highly qualified teachers from non-highly qualified teachers could

also add to the knowledge of successful professional development programs intended to

provide information to school districts that are providing training for their teachers to

become highly qualified in science. Because of the large standard deviation that was

measured for the PSTE scores, additional studies examining the cases at the extreme ends

of the scoring range would also make for an interesting study.

Teachers with high self-efficacy and outcome expectancy tend to believe that they

can guide their students through successful learning experiences and high levels of

achievement. Long-term professional development programs that encourage both aspects

of self-efficacy, personal science teaching efficacy, and student outcome expectancy

should be recognized as a key to achieving scientific literacy for all students. Outcome expectancy does not appear to be very predictive of student achievement in and of itself.

Although the researcher proposes value in long-term inquiry-based professional development programs for science teachers, caution is still warranted. The researcher cannot conclude that this type of inservice program solely brings about change in science teachers' beliefs. In conclusion, the researcher finds long-term inquiry-based professional development programs for science teachers necessary but not sufficient in bringing about belief and behavior change with science teachers. Teachers belonging to a social community that encourages learning together, discussing positive and challenging aspects of inquiry learning and having a supportive learning community (principals, peer faculty, parents) would also increase self-efficacy and outcome expectancy.

This study supports the importance of studying professional development programs conducted over long periods of time to measure changes in science teachers' self-efficacies and outcome expectancies. Information obtained by the researcher is an indication of the long-term impact in changing teachers' self-efficacy beliefs. These data strongly suggest the importance of not looking solely at the numerical rating on one instrument when analyzing self-efficacies and outcome expectancies of science teachers over time. Looking only at the numerical rating is incomplete and not a total picture of other contributing factors influencing science teachers' self-efficacy beliefs. Past studies have implied a relationship between self-efficacy, outcome expectancy, and other variables of interest; this study confirms that this relationship is a complex one. Results are encouraging to those who see long-term professional development as essential and therefore, future studies that consider examining other variables, as previously discussed,

may render valuable information to enhance the understanding of science teacher efficacy

beliefs.

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APPENDICES

APPENDIX A

PERMISSION LETTERS

The University of Akron

January 31, 2008

M. Kathleen Leslie Cripe
5694 Cider Mill Crossing
Youngstown, Ohio 44515

Ms. Cripe:

Your protocol entitled "*Evaluating Changes in Self-Efficacy after Active Involvement in a Science Inquiry Professional Development Project*" was determined to be exempt from IRB review on January 30 2008. The IRB application number assigned to this project is 20080116. The protocol represents minimal risk to subjects and matches the following federal category for exemption:

☒ **Exemption 1** – Research conducted in established or commonly accepted educational settings, involving normal educational practices.

☐ **Exemption 2** – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior.

☐ **Exemption 3** – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior not exempt under category 2, but subjects are elected or appointed public officials or candidates for public office.

☐ **Exemption 4** – Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens.

☐ **Exemption 5** – Research and demonstration projects conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine public programs or benefits.

☐ **Exemption 6** – Taste and food quality evaluation and consumer acceptance studies.

Annual continuation applications are not required for exempt projects. If you make changes to the study's design or procedures that increase the risk to subjects or include activities that do not fall within the approved exemption category, please contact the IRB to discuss whether or not a new application must be submitted. Any such changes or modifications must be reviewed and approved by the IRB prior to implementation.

Please retain this letter for your files. If the research is being conducted for a master's thesis or doctoral dissertation, the student must file a copy of this letter with the thesis or dissertation.

Sincerely,

Sharon McWhorter
Associate Director

☒ Approved consent form/s attached

Cc: Katharine Owens, Advisor
       Rosalie Hall, IRB Chair

Dear Participant,

As a part of my work in completing *&* doctoral degree from the University of Akron, I am researching the changes in self-efficacy of science teachers as a result of participating in a professional development program that will immerse them in learning science through inquiry. I am interested in your current beliefs about science teaching and how these beliefs may affect student outcomes and the changes that may take place as result of participation in this professional development program. To that end, I am seeking your responses to the completion of the Science Teaching Efficacy Belief Instrument (STEBI) and Demographics Survey. You will respond using campus computers. Information gained from these surveys will provide data that will indicate changes in teachers" beliefs about learning science through inquiry *based* on their experiences in completing this professional development program. You have an opportunity to learn the results of the study at its conclusion, if you so desire.

Anonymity and confidentiality of you, the respondent, will be protected throughout the survey tabulations and ensuing data reporting within the limits of the law. There are no risks to you by your participation. Participation in this study provides an opportunity for the subjects to change and improve their current teaching practices by teaming through inquiry and changing their self-efficacies about teaching through inquiry**.** You will not be asked, to give your name on the surveys. Your participation will not affect your grade in the professional development program. Although participation is voluntary, and you may refrain from answering any or all questions without penalty, your responses will be appreciated, and will add to the validity of the study. You may withdraw your participation of the study at any time. If you choose to participate, I will ask you to sign a statement of informed consent acknowledging that you have been informed about the nature of the study and give your permission to participate.

If you would like to receive a brief summary of the results of the study when it is concluded, please contact Kathleen L. Cripe at klc38@uakron.edu. You may direct questions about this study to Kathleen L. Cripe, Department of Curriculum and Instruction, University of Akron, (330) 792-4242 or via email at klc38@uakron.edu. The Institutional Review Board for the Protection of Human Subjects at The University of Akron has approved this research. Questions or comments can also be directed to the Institutional Review Board via Associate Director, Office of Research and Sponsored Programs, The University of Akron, Akron, Ohio, 44325-2102. Thank you for your assistance.

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Your signature below indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, and that you have received a copy of this form.

Signature   Date

Printed Name

Address

Department of Curricular and Instructional Studies
College of Education
Akron, OH 44325-4205
330-972-7765 Office
330-972-8150 Office
330-972-5209 Fax

APPENDIX B

DEMOGRAPHICS SURVEY

1. What is your gender?
   a. Female
   b. Male

2. What is your age?
   a. 25 or younger
   b. 26-30 years
   c. 30-34 years
   d. 35-39 years
   e. 40-44 years
   f. 45-49 years
   g. 50-54 years
   h. 55-59 years
   i. 60 years or older

3. What is your current professional position (select only one)?
   a. Intervention Specialist
   b. Classroom Teacher
   c. Science Resource Teacher
   d. District or School-Based Administrator
   e. Other

4. If you answered to the last question "What is your current professional position?"
   please type the details here. If not, please leave blank and save.
Answer:

5. How many total years have you taught students in grades K-6?
Answer:

6. How many total years have you taught students in grades 7-12?
Answer:

7. Are you a Highly Qualified Teacher of Science?
   a. Yes
   b. No

8. If you answered YES to the question "Are you a Highly Qualified Teacher of Science?", please specify which area(s):
Answer:

9. What is the number of college science courses you have completed?

10. List the school district where you are employed_____.

APPENDIX C

HIGHLY QUALIFIED STATUS

Section 1: A minimum of a bachelor's degree; AND
Section 2: Full state certification/licensure in the teacher area; AND
Section 3: One of the following:

1. Ohio's State Licensing Exam
2. Academic major or 30 hours in content area
3. Master's Degree
4. 8-year Professional Certificate
5. Permanent Certificate
6. National Board Certification
7. HQT Rubric-scored 100 points or more
8. 90 completed and Approved Clock Hours of Professional Development
    distributed over the following areas; grade appropriate academic subject matter
    knowledge, teaching skills and Ohio's Academic Content Standards. These hours
    were included in an Individual Professional Development Plan that was approved
    by a LPDC (Local Professional Development Committee).

APPENDIX D

SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT: STEBI-FORM A

BY IRIS M. RIGGS Ph.D. AND LARRY G. ENOCHS Ph.D.

Please indicate the degree to which you agree or disagree with each statement below by choosing the appropriate letters to the right of each statement.

SA = STRONGLY AGREE, A = AGREE, UN = UNCERTAIN, D = DISAGREE, SD = STRONGLY DISAGREE

1. When a student does better than usual in science,   SA   A   UN   D   SD
    it is often because the teacher exerted a little extra effort.

2. * I am continually finding better ways to teach science.   SA   A   UN   D   SD

3.* Even when I try very hard, I don't teach science as SA   A   UN   D   SD
    well as I do most subjects.

4. When the science grades of students improve, it is SA   A   UN   D   SD
    most often due to their teacher having found a more
    effective teaching approach.

5.* I know the steps necessary to teach science   SA   A   UN   D   SD
    concepts effectively.

6.* I am not very effective in monitoring.   SA   A   UN   D   SD

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7. If students are underachieving in science, it is most likely due to ineffective science teaching.　　SA　A　UN　D　SD

8.* I generally teach science ineffectively.　　SA　A　UN　D　SD

9. The inadequacy of a students' science background can be overcome by good teaching.　　SA　A　UN　D　SD

10. The low science achievement of some students cannot generally be blamed on their teachers.　　SA　A　UN　D　SD

11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.　　SA　A　UN　D　SD

12.* I understand science concepts well enough to be effective in teaching elementary science.　　SA　A　UN　D　SD

13. Increased effort in science teaching produces little change in some science achievement.　　SA　A　UN　D　SD

14. The teacher is generally responsible for the achievement of students in science.　　SA　A　UN　D　SD

15. Students' achievement in science is directly related to their teachers' effectiveness in science teaching.　　SA　A　UN　D　SD

16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.　　SA　A　UN　D　SD

17.* I find it difficult to explain to students why science experiments work.　　SA　A　UN　D　SD

18.* I am typically able to answer students' science questions.   SA   A   UN   D   SD

19. * I wonder if I have the necessary skills to teach science.   SA   A   UN   D   SD

20. Effectiveness in science teaching has influence on the achievement of students with low motivation.   SA   A   UN   D   SD

21.* Given a choice, I would not invite the principal to evaluate my science teaching.   SA   A   UN   D   SD

22.* When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.   SA   A   UN   D   SD

23.* When teaching science, I usually welcome student questions.   SA   A   UN   D   SD

24.* I don't know what to do to turn students on to science.   SA   A   UN   D   SD

25. Even teachers with good science teaching abilities cannot help some kids learn science.   SA   A   UN   D   SD

* Personal Science Teaching Efficacy statements.

APPENDIX E

FIFTH GRADE LESSONS AND ACTIVITIES ALIGNED TO OHIO

ACADEMIC SCIENCE CONTENT STANDARDS

CONTENT	ACTIVITIES
LIFE	• Owl Prowl Lesson- Benchmark B; Grade Level Indicator (GLI) 2, and 3
	• Food Web and Energy Flow – Benchmark B, GLI 1, 3; Benchmark C, GLI 6
	• Neighborhood Ecosystems- Benchmark C, GLI 5, 6
	• Water Pollution Solutions- Benchmark C, GLI 6
	• Monkey Dung Lesson- Benchmark C, GLI 4
	• The legend of the Three Sisters-(Diversity and Interdependence of Life), GLI 1, 4, 5, 6
	• Windows on Waste Separation Mania-(Diversity and Interdependence of Life), GLI 4, 6
EARTH & SPACE	• Kinesthetic Astronomy
	• Sky Time Activity
	• Body Shadows -Benchmark A, GLI 1
	• Water Pollution Solutions-, Benchmark C, GLI 6
	• Series and Parallel Circuits
	• The legend of the Three Sisters-(Earth Systems), GLI 5, 6
	• Windows on Waste Separation Mania-(Earth Systems), GLI 5, 6
PHYSICAL	• Light Bounce
	• Light Stations- Benchmark F, GLI 5
	• Sound Stations- Benchmark F, GLI 6, 7

	• Exploring Variables Chocolate Chip Challenge- Benchmark D, GLI 2
	• Goldilocks and Thermal Energy- Benchmark B
	• Solar Cooking- Benchmark D, GLI 1,2
	• Is It Hot Thermal Energy- Benchmark D, GLI 1
	• Lights, Camera, Action
	• Electric Current- Benchmark E, GLI 3, 4
	• Magnets
	• Making Connections
	• Demystifying Misconceptions
	• Series and Parallel Circuits
	• Shoe-Science- Benchmark E
	• Structures are Electrifying Work-(Nature of Energy), GLI 3, 4
SCIENTIFIC INQUIRY	• Hidden Monsters
	• Light Stations- Benchmark B, GLI 2
	• Sound Challenge- Benchmark B, GLI 2, 3
	• Exploring Variables Chocolate Chip Challenge- Benchmark B, GLI 2,3; Benchmark C, GLI 4, 5, 6
	• Goldilocks and Thermal Energy- Benchmark A
	• Solar Cooking- Benchmark A, GLI 1; Benchmark B, GLI 2,3; Benchmark C, GLI 4, 5, 6
	• Is It Hot Thermal Energy- Benchmark A, GLI 1; Benchmark B, GLI 2.
	• Lights, Camera, Action
	• Magnets
	• Making Connections
	• Demystifying Misconceptions
	• Series and Parallel Circuits
	• Monkey Dung Lesson- Benchmark B, GLI 2, 3
	• Shoe Science- Benchmark B, GLI 3
	• Structures are Electrifying Work-(Doing scientific inquiry), GLI 1 – 6
	• Windows on Waste Separation Mania-(Doing Scientific Inquiry), GLI 2, 3
SCIENTIFIC WAYS OF	• Hidden Monsters

KNOWING	• Light Stations- Benchmark C, GLI 2
	• Shoe Science- Benchmark B, GLI 2, 3
	• Sound Challenge- Benchmark B, GLI 3
	• Structures are Electrifying Work-(Nature of Science), GLI 1-4
	• Windows on Waste Separation Mania-(Nature of Science), GLI 1, 2; (Ethical Practices), GLI 5; (Science and Society), GLI 1
SCIENCE & TECHNOLOGY	• Sound Challenge- Benchmark B, GLI 2
	• Exploring Variables Chocolate Chip Challenge- Benchmark A, GLI 2
	• Solar Cooking- Benchmark B, GLI 2
	• Neighborhood Ecosystems- Benchmark A, GLI 1
	• Water Pollution Solutions- Benchmark A, GLI 1; Benchmark B, GLI 3
	• Structures are Electrifying Work-(Abilities to do Technological Design), GLI 2, 3
	• The legend of the Three Sisters-(Understanding Technology), GLI 1; (Doing Scientific Inquiry), GLI 3, 4, 6
	• Windows on Waste Separation Mania-(Ability to do Technological Design), GLI 2,3

Fifth Grade Teaching Topics

TEACHING TOOLS	OTHER
• Tools of Science – Lesson overview of various laboratory apparatus	• Introduction and Overview of Professional Development Program
• Word Walls– New vocabulary covered in activities	• Safety in the Classroom
• Constructivism and the Five E's –(Teaching Philosophy and explanation of engage, explore, explain, elaborate, and extend)	• NSTA Teacher Resources
• Ohio Benchmarks & Indicators Grades 3, 4, 5	• Variables Presentations
• Essential Features of Inquiry	• Thermal Energy Teaching Notes – Content for teachers
• Essentials of Learning Cycle	• Ohio Grade 5 Science Achievement Test Blueprint – Layout of the OAT for science achievement.
• Concept Mapping in Science	• Testing for Ohio Achievement tests – Discussion of Ohio's Comprehensive Assessment System.
• Concept Map Rubric	• Gender Issues – Discussion of gender inequities in science.
• Sound and Light Venn Diagram	• IMS Tips – Investigating the Instructional Management System on the Ohio Department of Education website.
• Linear Measurement Fun	• Models and Analogies – Science content for teachers
• Science Lesson Evaluation Rubric	• The Microscope – Content for teachers on proper use of microscopes.
• Neighborhood Ecosystems Journal – Graphic organizer used to review and summarize lesson.	• Disney ending – Participants present information learned and what they hope to learn in follow-up sessions.
• Anticipation Guide and Reading	• Monkey Dung – scenario cards – Teacher content
• 20 Questions	• Student work-facilitator – Participants share student work samples
• Products and Assessments	• Collected Power Point questions – Participants have opportunity to discuss strengths and weaknesses of professional development program.
• Performance assessment rubric – Rubrics used for activities	• Science Links – Teachers helping teachers websites
• Energy Boost with Standards	• Excel Cheat Sheet – Teaching tips for using Excel Programs
• Classroom based intervention – Differentiation	• Microsoft Tutorial for Chart Wizard – Participants learn how to create charts, tables, and graphs in Microsoft Excel
• Double Entry Journal	
• Three Parts of an Aligned Educational System	
• Test Prep Adaptations without much extra work	

APPENDIX F

ABILITIES NECESSARY FOR SCIENTIFIC INQUIRY

K-4

- Ask a question about objects, organisms and events in the environment
- Plan and conduct a simple investigation
- Employ simple equipment and tools to gather data and extend the senses
- Use data to construct a reasonable explanation
- Communicate investigations and explanations

5-8

- Identify questions that can be answered through scientific investigations
- Design and conduct a scientific investigation
- Use appropriate tools and techniques to gather, analyze and interpret data
- Develop descriptions, explanations, predictions and models using evidence.
- Thing critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

9-12

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.