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A Study of the Teaching Beliefs of GLOBE Teachers

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A STUDY OF THE TEACHING BELIEFS OF GLOBE TEACHERS

by

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ABSTRACT

The purpose of this study was to explore the teaching beliefs of GLOBE (Global Learning and Observations to Benefit the Environment) teachers, and to analyze their pedagogical practices. This study contributes to bridging the gap between our understanding of teachers' beliefs of teaching science with inquiry and practicing science in class with inquiry. A descriptive research approach was used for both quantitative and qualitative analysis. Data was collected from seventy-two trained GLOBE teachers across the U.S. using Qualtrics.com.

Quantitatively, the pedagogical beliefs of GLOBE teachers were measured using the Beliefs about Reformed Science Teaching and Learning (BARSTL) questionnaire. Differences between the scores of BARSTL and demographic data were analyzed using the one-way ANOVA with SPSS. Necessary follow-up analysis, including post hoc tests, were done where significance was found. Qualitatively, their teaching experiences were investigated using their responses from an open-ended questionnaire in an instrument referred to as the Teaching after Globe Training Questionnaire (TGTQ).

The BARSTL scores from this study revealed that the vast majority (93.06%) of the GLOBE teachers were inclined towards constructivist teaching beliefs. The one-way ANOVA results showed no significance for age and years of teaching experience. The regions showed the significant differences possibly because of small sample size and uneven distribution of the sample in each region. Results from the TGTQ highlighted the struggles and challenges teachers faced during classroom practices.

Sixty-one percent of the teachers had changed their teaching strategies after learning GLOBE protocols and incorporated more hands-on inquiry-based activities in their

teaching. Eighty-two percent of the teachers planned to continue teaching with GLOBE activities and protocols. Almost all of the teachers believed that teaching with GLOBE had influenced their students' learning, and they indicated that both accelerated and regular students learned better with GLOBE investigations. The results from this study revealed that GLOBE teachers believed that GLOBE training had influenced their teaching skills and improved their scientific concepts. The results also explained how some GLOBE teachers modified their classroom teaching practices and continued using GLOBE while others discontinued. Thus, we may conclude that GLOBE training positively influences teachers' teaching beliefs and practices.

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DEDICATION

The writer would like to dedicate this dissertation to Jane Ali, her mother-in-law, without whom she would have never entered the teaching profession. Without her guidance and support none of this would have been possible.

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1.1 Overview of Teachers' Beliefs.

There is a connection between teaching beliefs and teaching practices in science education (Smith & Southerland, 2007). Both teaching beliefs and practices are important concepts but are considered vague, complicated, not well understood, and need analysis (Acikalin, 2009). In order to understand these vital concepts, it was essential to investigate beliefs about science teaching and learning and to know how interested a particular teacher might be to an inquiry-based constructive classroom. (Sampson, Grooms, & Enderle, 2013). This was accomplished by exploring the teaching beliefs and practices of teachers trained in GLOBE (Global Learning and Observations to Benefit the Environment). In the GLOBE program, teachers are trained in protocols for use in inquiry-based, hands-on science teaching. This study was performed by using a descriptive research approach comprising of both quantitative and qualitative analyses.

There have been many studies conducted on teaching beliefs in educational literature (Fang, 1996; Kagan, 1992; Mansour, 2009; Nespor, 1987; Pajares, 1992). However, there is still a need to better understand the differences between teacher beliefs and their teaching practice (Crawford, 2007). Luft (2001) studied the effect of inquiry-based professional development programs on the beliefs and practices of college and high school science teachers, and found that even though their teaching practices changed, their beliefs did not. Teachers embrace beliefs concerning professional practices which, in turn, trigger their actions (McComas, Clough & Almazroa, 2002). Teachers' beliefs play a vital role in restructuring science education (Irez, 2006). Research has shown that if the implementation of a curriculum did not consider the beliefs of the teachers, that curriculum would not be successfully implemented into the classroom (Cronin-Jones 1991). Beliefs are resilient and difficult to change (Yerrick, Parke, & Nugent, 1997) and, therefore, more influential in affecting attitudes (Mcllmoyle, 2010).

1.1.1 Inquiry and Science Education.

Inquiry is always considered an important objective of science education (Abd-El-Khalick et al., 2004; Dewey, 1910; Minner, Levy, & Century, 2010; Rutherford, 1964). The National Research Council (2000) considered inquiry an important feature for science teaching and demanded teachers to have specific knowledge to develop and plan scientific investigations, including data collection, interpretation, and presentation (Gess-Newsome & Lederman 1999; Shulman, 1986). Inquiry-based science teaching is an important issue identified by the National Science Education Standards (1996) in the Benchmarks for Scientific Literacy (American Association for the Advancement of Science, 1993)**.** The National Research Council (1996) recognized “inquiry into authentic questions generated from student experiences (as being) the central strategy for teaching science” (p. 31). The Council also instructed science teachers to implement teaching strategies in an open-ended approach to inquiry that “nurtures a community of science learners” (p. 26). Open-ended inquiry gave an opportunity to the students to connect beyond the classroom directly with the scientific and political world.

The goal of implementation of open-ended inquiry in science has been the requirement for a professional development program that could diminish teacher misunderstanding relating to active teaching and learning science (Wee, Shepardson, Fast & Harbor, 2007). Such professional development needs to incorporate a “hands-on, minds-on" approach, which is constructivist pedagogical integration. (Kimble, Yager, & Yager, 2006).

For over two decades, several efforts had been made to teach science in classrooms using inquiry. The presentation of open-ended inquiry would require significant changes in teacher thinking and instructional practices which were identified as difficult to accomplish. (Blumenfeld, Soloway, Marx, Krajcik,, Guzdial & Palincsar, 1991; Wee, Shepardson, Fast & Harbor, 2007). Supovitz and Turner (2000) determined that individual teachers' content knowledge had a strong effect on his or her uses of inquiry-based practices and investigative classroom beliefs. Teachers' beliefs about inquiry had been recognized as a principal source of which they accept or reject inquiry teaching and learning theories and practices (Keys & Bryan, 2001; Zhang et al., 2003). Theories, beliefs, values and understandings have been considered important for the inquiry approach of teaching (Anderson, 2002).

1.1.1.1 Role of Teaching Beliefs.

Teaching beliefs are the perceptions and attitudes carried by a teacher about their situation and their personality in the teaching environment (Cross, 2009). For example, some teachers may believe that students could learn scientific concepts through group activities, and they teach students by allowing them to work in groups. However, other teachers may believe that working in groups is not appropriate for teaching and would serve as a disruption in class. These teachers would find the traditional lecture method of instruction suitable for their classes. If a teacher was asked to implement an idea in the classroom which they either did not believe to be correct or did not fully understand, of course it would not succeed. Teaching beliefs function like a lens through which teachers infer new ideas and teaching methods (Sampson, Grooms, & Enderle, 2013). The authors state that teaching beliefs not only outline how a teacher identified new ideas, but also how they would apply them in classroom teaching. Research suggested that if a teacher's beliefs are not compatible with the philosophy of their curriculum, it would not be successfully implemented in the classroom (Cronin-Jones, 1991).

Despite how many teachers participate in state and national professional development programs and collaborate with university-based researchers to improve their own science learning and teaching, implementing reform-based, constructivist pedagogy in the classroom is challenging (Lotter, Harwood & Bonner, 2007). Researchers have stated that teachers' teaching beliefs are reflected in their practice (Crawford, 2007; Haney, Lumpe, Luft, 2001; Stipek et al., 2001; Wallace & Kang, 2004). This encourages teachers' decisions and actions (Keys & Bryan, 2001; Pajares, 1992), and it may be considered as a filter for accepting or rejecting new information (Pajares, 1992; Wallace & Kang, 2004).

Teaching beliefs have been studied by various researchers and educators for decades (Fang, 1996; Kagan, 1992; Mansour, 2009; Nespor, 1987; Pajares, 1992). In 2013, Dr. Sampson, Grooms and Enderle developed a new instrument, The Belief about the Reformed Science Teaching and Learning (BARSTL), to examine how interested a particular teacher might be to an inquiry-based constructive classroom. This instrument could also be used to develop and validate teachers' beliefs about science teaching and learning (Sampson, Grooms, & Enderle, 2013). The BARSTL measures the teaching beliefs of a given instructor in four key areas: How People Learn about Science, Lesson

Design and Implementation, Characteristics of Teachers and the Learning Environment, and the Nature of the Science Curriculum (Sampson, Grooms, & Enderle, 2013).

1.1.1.1.1 Overview of GLOBE Program.

The GLOBE program (www.globe.gov) was established in 1995 with funding and collaboration from multiple federal agencies to initiate projects in the fields of science and education. These include the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and the Department of State. NASA and NOAA scientists stay involved with the GLOBE program to accomplish its scientific and educational mission. The GLOBE program provided an opportunity for teachers to incorporate scientific and environmental research into their own classrooms. More than 100 countries manage and support this program and over 58,000 teachers had been instructed on various GLOBE protocols. Last year the GLOBE program celebrated 22 years and has been contributing towards science, technology, education and mathematics (STEM) by sharing scientific data globally (The GLOBE Program, www.globe.gov).

GLOBE is a hands-on, school-based science and education program that involves teachers, students and scientists in study and research that aims at increasing scientific understanding of the Earth, improving student achievement in science and mathematics, and enhancing the environmental awareness of individuals worldwide. It focuses on using appropriate scientific methods that include hypothesis, data collection, analysis and conclusion. Data collection is guided by protocols that had been validated and utilized in K-12 classes. It has been consistent with National Science Education, the Next Generation Science Standards, and the National Social Studies Standards and implemented around the world (www.globe.gov, Iowa Academy of Science and Seavey, 2014).

The GLOBE teachers and educators around the world receive professional development training for the implementation of GLOBE pedagogical models based on inquiry. Local partners provide support and training to GLOBE teachers, regardless the level of students they teach. They learn how to use GLOBE protocols by attending GLOBE Teacher Training Workshops or by completing GLOBE e-training certification. In these workshops, teachers receive knowledge and tools to implement GLOBE protocols and learn how to conduct activities in classroom setting working with their students to make data observations. The GLOBE program also has online tools to help teachers interpret the alignment of GLOBE activities with their local standards.

The salient feature of the GLOBE program is that it follows inquiry-based science education. Inquiry-based science education was promoted by the National Science Education Standards (1996) and now by the Next Generation Science Standards (NGSS, 2014). Connections between the GLOBE program and the NGSS was delineated by the Iowa Academy of Science and Seavey (2014). Students following GLOBE protocols not only collect scientifically useful data but also report it to the program's website which is regularly updated (Penuel & Means, 2003). This gives them a true research experience and makes them feel like a true scientist by contributing their data. The GLOBE program's philosophy has always been to provide resources, but it leaves the decisions related to curriculum to teachers. Teachers are allowed to introduce any investigation, activity or protocol to the students and devote as much time to GLOBE as they could by adjusting their teaching.

1.2 Statement of Problem.

The relationship between teaching beliefs and practices are considered complex and are not well understood (Acikalin, 2009). The assumptions of the GLOBE program led to questions regarding how GLOBE teachers integrated GLOBE into their teaching. Do GLOBE teachers shared common teaching beliefs? What kind of hurdles GLOBE teachers faced during classroom teaching? The goal of this study was to explore the teaching beliefs and practices of GLOBE teachers by using descriptive research approach. The proposed study explored the pedagogy and teaching beliefs of GLOBE teachers during classroom practices.

1.3 Purpose.

The purpose of this research was to investigate the teaching beliefs of GLOBE teachers and to analyze their pedagogy and practices using a descriptive research approach. A graphic illustrating the constructs explored in this study is presented in figure 1.1. Teaching beliefs about GLOBE, using inquiry-based activities in the classroom, conducting scientific investigations, and GLOBE workshops and their effect on teachers' pedagogical content knowledge (PCK) were explored in this study. The instrument 'Belief about the Reformed Science Teaching and Learning' (BARSTL) was used to collect quantitative data on participants' pedagogical beliefs. Information obtained from the Teaching after GLOBE Training Questionnaire (TGTQ) was used to collect qualitative data on teachers' classroom practices, scientific knowledge, and student learning. Differences between BARSTL scores and demographic factors were explored: age of teachers, number of years of teaching experience, type of GLOBE investigation trained in, grade level of students, subject taught, region, and type of institute (private or public) where they taught. The study determined how GLOBE teachers implemented GLOBE activities in their classrooms and if GLOBE program training and experience changed their teaching beliefs, teaching practices, and scientific knowledge.

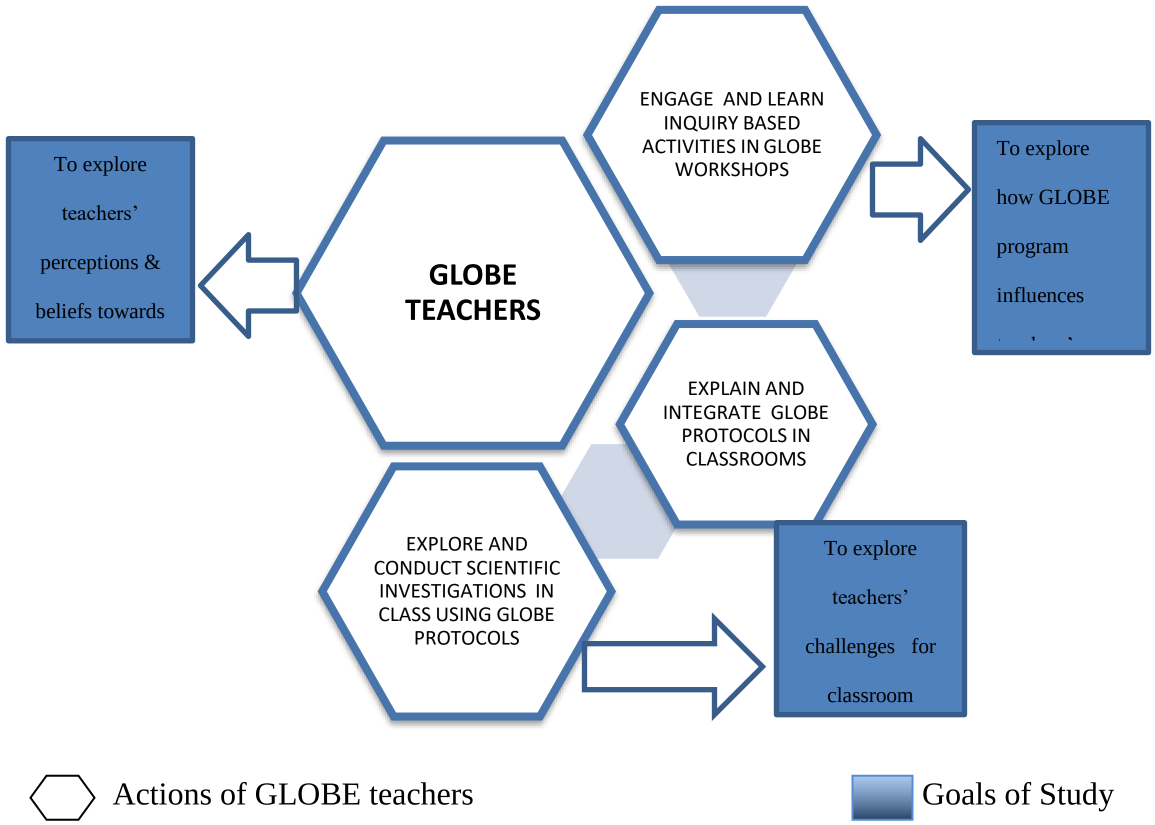


Figure 1.1 Purpose of Research Study

(A graphic illustration explaining the constructs explored in the study is shown in the above figure).

1.4 Justification for Study.

This research study would contribute to bridging the gap between our understanding of teachers' beliefs of teaching science with inquiry and practicing science in class with inquiry. "It is important to examine a teacher's conception (view) of inquiry" but also maintain that such studies must include a teacher's context of practice (Crawford, 2007). This study responded to Crawford's position by including the experience of science teachers' views of teaching and learning in relation to inquiry while using the GLOBE program in their classroom practices.

Over the years, researchers have assessed and studied the GLOBE program, the barriers to implementation, (Means et al., 2001), and factors associated with different levels of implementation (Penuel & Means, 2004). These included case studies of different schools and works to implement the curriculum (Means et al., 1999; Penuel, Shear, Korbak & Sparrow, 2005). This study focused on challenges, as well, including how to maintain cognitive engagement of students while teaching inquiry (Krajcik, et al., 1994).

A descriptive research approach was used to conduct this research study. In this research study the perceptions and beliefs of teachers engaged in inquiry-based classroom practices were explored and measured. Quantitatively, GLOBE teachers' beliefs were measured using the BARSTL questionnaire. The BARSTL instrument was developed in order to assess the degree to which science teachers' beliefs about the teaching and learning of science were aligned with current science reform movements which supports constructivism (Sampson et al., 2013). It was assumed that teachers with different or traditional perspectives about teaching and learning science would reflect differently on the BARSTL continuum (Sampson et al., 2013). Similarly, the results from this study reflected where GLOBE teachers' stand on the BARSTL continuum and if they varied across regions in the U.S. The teachers' responses provided insight into their thoughts of how science should be taught which would help to improve science pedagogy practices.

Qualitatively, the influence of GLOBE training on teachers' practices and knowledge was explored using the TGTQ questionnaire. In addition, demographic differences which included state, age, subject, grade level of students taught and type of institute (public or private) where the teachers taught, number of years of experience and GLOBE investigations they were trained in, were also explored and compared to better understand the differences between teaching beliefs and teaching practices. Comparisons were made between teachers who continued to teach with GLOBE and those who discontinued using it in class.

1.5 Research Questions.

The TGTQ will be used to answer research questions 1 through 8. The BARSTL will be used to answer research questions 9 and 10. Both instruments will be used to answer questions 11 through 16.

1. How do GLOBE teachers integrate GLOBE protocols and investigations into their classroom practices?

2. Why do teachers integrate GLOBE activities in their teaching?

3. How do teachers implement GLOBE activities to enrich STEM education in class?

4. What types of challenges do teachers report in implementing GLOBE investigations into classroom practices?

5. What kind of successes do teachers experience while implementing GLOBE activities?

6. In what way has GLOBE training influenced teachers' scientific knowledge?
7. How do GLOBE teachers believe GLOBE involvement in the classroom influences their students' learning?
8. How do teachers change their teaching strategies after learning GLOBE?
9. Where do GLOBE teachers lie on the BARSTL continuum?
10. Where do GLOBE teachers lie on individual BARSTL components (how people learn about science, lesson design and implementation, characteristics of teachers and the environment, the nature of science curriculum)?
11. Is there a significant difference between the total BARSTL score and number of years these teachers have taught?
12. Is there a significant difference between each of the 4 component scores of the BARSTL and the number of years these teachers have been teaching?
13. Is there a significant difference between the total BARSTL score and the region where these teachers have taught?
14. Is there a significant difference between each of the 4 component scores of the BARSTL and the region in which they have been teaching?
15. Is there a significant difference between the total BARSTL score and the age of these teachers?

16. Is there a significant difference between each of the 4 component scores of the BARSTL and the age of teachers?

1.6 Definitions of Terms.

The following terms were defined as follow:

1. *GLOBE teachers* – those teachers who have received training for the implementation of GLOBE protocols and activities for inquiry-based learning regardless of grade levels. They learn how to use GLOBE protocols by attending GLOBE Teacher Training Workshops or by completing GLOBE E-Teacher certification.

2. *Reform-based science curriculum* – an inquiry-based unit or course which is aligned with constructivist learning theory.

3. *How People Learn about Science* – a BARSTL category describing how a teacher believes their students learn about science. This includes thoughts on students' natural abilities in science, as well as beliefs about the overall structure of the classroom setting, such as whether or not open and lively discussion is initiated in the classroom.

4. *Lesson Design and Implementation* – a BARSTL category describing how a teacher believes a science lesson should be designed and taught in school. This includes understandings on experiments and inquiry-focused techniques in the classroom.

5. *Characteristics of Teachers and the Learning Environment* – a BARSTL category describing how a teacher believes instructors should act and how their classrooms should be run. This category focuses on what role students should play in the learning process. Another part of this category is whether the teacher believes individual or group focused assignments are best for his or her students.

6. *The Nature of the Science Curriculum* – a BARSTL category describing how an instructor believes the optimal science curriculum should be designed. Should a curriculum be broadly designed but narrow in that it only covers a few important topics from each section, or should it be narrowly focused but deep, so that students will master a few key ideas instead?

7. *Inquiry- based teaching* – a student-centered method of teaching using hands-on approach, and the teacher acts as a facilitator.

1.7 Delimitations.

This study was limited to GLOBE-trained teachers in the U.S.

1.8 Assumptions.

1. It is assumed that instructors answered the questions based on what they believed is proper in the classroom, rather than what they thought we wanted to hear.
2. It is assumed that all instructors understood English sufficiently to be able to read and responded to the questions in a cogent manner.

CHAPTER II – REVIEW OF THE LITERATURE

There are connections between teachers' beliefs and classroom practices (Maor and Taylor, 1995). Teachers are required to learn how to teach constructively, obtain new assessment capabilities, and perform innovative teaching tasks according to the requirements of their students and schools. Teachers face various barriers and challenges in teaching through inquiry, many of which have their roots in their beliefs. Therefore, teachers' beliefs are considered important for classroom practices (Anderson, 2002).

2.1 Teachers' Beliefs versus Knowledge.

Teachers' beliefs may be referred to as their philosophy, convictions, tenants or opinions about teaching and learning. Clark and Patterson (1985) suggested that teachers and their beliefs play an important role in science education as their actions influence students. Both future and in-service teachers develop their beliefs from the years they spent in the classroom as students (Perry, 1990). Whereas beliefs are formed internally by non-consensus from expressive feelings as well as personal experiences, knowledge is the cognitive result of thought. Beliefs could not be evaluated or appraised, but knowledge is external and needs evaluation or judgement to reach consensus. Beliefs are the affective outcome of knowledge. Beliefs are far more dominant than knowledge in influencing responses and are less likely to be changed. Beliefs are more persuasive than knowledge in influencing behavior and are shaped during earlier experiences, and become robust over time as they are utilized during successive practices. Beliefs play an important role in outlining teachers' goals and behaviors and in establishing knowledge (Pajares, 1992).

A number of studies suggested that teachers' content knowledge is associated with the science teaching strategies they use (Carlsen, 1993; Cronin-Jones, 1991; Hollon, Roth & Anderson, 1991). Knowledge forms a structure of beliefs and attitudes which guided teacher perception and belief (Fang, 1996) whereas beliefs are defined as “supposition, commitments, and ideologies” (Calderhead, 1996). It was noticed that it was a lack of content knowledge and confidence of elementary teachers to teach science and effectively influence student learning (Crawford, 2000). Teacher perceptions and beliefs are steered by a construction of beliefs and attitudes formed by knowledge while knowledge could be considered as “factual propositions and understanding”. (Mcllmoyelle, 2010; Prestridge, 2012).

2.2 Teaching Beliefs, Science Teaching and Classroom Practice.

Ernest (1989) stated that teachers’ beliefs about teaching, learning, and the nature of the subject have the greatest influence on classroom practice. A teacher’s beliefs about science, learning, and science teaching are revealed in every feature of their practice because beliefs are like sifters through which actions are observed and this results in decisions (Kagan, 1992). Pajares (1992) argued that to improve teachers’ practices, it would be important to understand teachers’ beliefs. For science teachers, the nature of the subject is referred to their ‘nature of science’ beliefs.

The association between nature of science beliefs and teaching practice has been researched in various studies (Bryan, 2003; Eick & Reed, 2002; Lederman, 1999; Lederman & Zeidler, 1987; Tobin & McRobbie, 1997; Trumbull et al., 2006). These researches suggested that there is a correlation between teachers’ beliefs about the nature of science and the teaching practices in the classroom which may be influenced by various factors. Some science educators propose that the beliefs of teachers have a one-way effect on their practices (Pajares, 1992). However, others proposed that there are mutual differences between teachers' beliefs and practices, one impacting the other.

Teaching beliefs are sturdy and hard to change, even when the teacher wants to change (Yerrick, Parke, & Nugent 1997). In *Struggling to Promote Deeply Rooted Change,* Dr. Yerrick, et al., (1997) organized a two-week summer institute for middle-grade science teachers. Their goal was to modify what science instructors believed about the nature of scientific content in their courses and the role that students played in the classroom. The teachers were taught about the importance of inquiry-oriented science curriculum and framework. It was found through interviews of participating science teachers that despite dynamic efforts and wholehearted participation by teachers, the belief system of the teachers did not considerably change. This study explained the differences of teaching beliefs and practice. Since the teachers believed more in implementing the traditional science curriculum, even after making efforts and training, they were not ready to adopt the changes.

Teachers' beliefs concerning students and student learning, the nature of science, student knowledge, and the part of the teacher in the classroom are all fundamentals of the teacher belief system. For example, Feldman (2002) carried out a case study of two high school physics teachers to study the implementation of reformed physics curriculum. He observed that both the teachers taught the same curriculum in different ways. The teacher who believed in critical thinking taught physics daily, and the teacher who did not believe in it did not teach it regularly and eventually stopped teaching the new curriculum. He concluded that the difference in implementation of the reformed physics curriculum was due to differences in teachers' beliefs. Thus, teachers' beliefs influence teaching practices and could impact the implementation of reformed-based curricula. Therefore, teachers' teaching beliefs must align with curriculum and are important for curriculum development. Similarly, Gregoire (2003) also found that teachers' beliefs influenced the teaching of reformed science curricula. The National Standards-based reform was constructed on the supposition that science knowledge is built; it could be seen that teachers who believed in nature of science knowledge are more likely to teach the reformed science curricula as their beliefs align with it (Kang, 2008; Kang & Wallace, 2004).

Smith and Southerland (2007) studied the differences between teaching beliefs and practice to study the science education reform efforts of teachers. During a case study of two teachers, they observed that although both the teachers believed in constructivism, their beliefs only moderately shaped their understanding of reform efforts. They concluded that in this case circumstantial factors played an influential role in determining these understandings. The findings of this study suggested a connection between teacher belief and practice, one where external forces impacted beliefs about science learning and teaching. These included the teacher preparation programs influencing these important beliefs about science learning. Similarly, although many teachers participated in various state and national training workshops for professional development to improve their science learning and teaching, implementing reform-based pedagogy in the classroom was still difficult (Lotter, Harwood & Bonner, 2007; Luft, 2007).

Crawford (2007) studied a biology teacher teaching open-ended inquiry and found that beliefs affected teaching practices and attitudes. Hence, without alignment between teachers' beliefs about knowledge in science and effective method to teach science, teachers may not be likely to carry out inquiry-based instruction (Roehrig & Kruise, 2010). Teachers' beliefs are dynamic aspects which are closely interrelated with their teaching practices, specifically in the case of the use of inquiry instruction (Hong & Vargas, 2015).

2.3 Concept of Pedagogical Content Knowledge.

In the 1980s, a major development had an influence in the conceptualization of teacher content knowledge. In 1985, Lee Shulman identified a special domain of teacher knowledge, which he discussed as pedagogical content knowledge (PCK). Shulman (1986) connected effective teaching to three of these types of knowledge: content or subject matter knowledge (SMK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK).

According to Shulman (1986), PCK includes teacher's abilities to use relevant and accurate analogies, illustrations, examples, explanations and demonstrations. It identified the distinctive bodies of knowledge for teaching. PCK represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are planned, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. PCK is the category most likely to distinguish the understanding of the content specialist from that of the teacher (Shulman, 1987).

PCK is the firsthand knowledge and skills gained through classroom experience (Van Driel, Beijaard, & Verloop, 2001), and PCK is the assimilated set of knowledge, concepts, beliefs and values that teachers cultivated in the setting of the teaching condition (Loughran, Mulhall, & Berry, 2004). PCK is a mixture of content and pedagogy that is crafted by teachers in a special way related to his or her professional knowledge and understanding. It is comprised of teachers' integrated knowledge, which they learned with teaching practice, pedagogy, students, subject matter, and the curriculum (Berry, 2004). The classrooms of two teachers teaching the same course in the same school can look absolutely different (Buoni, 2012).

2.4 Other Models of PCK and Science Teaching.

PCK is a concept which consisted of numerous components and could be presented in the form of models. PCK researchers had understood and used Shulman's initial construct to organize PCK components. Grossman's model of PCK (1990) had four components, namely, the conception of purposes for teaching subject matter, knowledge of students' understanding, curricular knowledge, and the knowledge of instructional strategies. Grossman considered the conception of purposes for teaching subject matter as the most important element of PCK, as it revealed the goal of teaching. Grossman's model was commonly used for teaching linguistic skills, including English, but was also widely criticized because he treated each component of PCK as independent.

Cochran's (1993) model emphasized the robust nature of PCK in that it continuously developed and consisted of four types of knowledge: SMK, PK, knowledge of context (environment & situation) and knowledge of PCK. According to him, teachers developed their knowledge continuously through teaching experience and other networks. Veal, Tippins, and Bell (1998) reported the need for science teacher education programs to develop topic-specific PCK in prospective teachers to help develop specific teaching strategies.

Magnusson et al. (1999) designed a PCK model specifically for science teaching. Components of this model included orientation to teaching science, knowledge of science curriculum, knowledge of students' understanding of science, knowledge of instructional strategy, and knowledge of assessment of science literacy. Magnusson's model was widely used in PCK researches. For example, Friedrichsen and Dana (2005) recognized features that effect the development of science teaching orientations. They concluded that beliefs about science teaching and the details were often unspoken and difficult to describe. They found that teaching orientation included three magnitudes: beliefs about the goals or objectives of science teaching, beliefs about the nature of science, and beliefs about science teaching and learning.

2.5 PCK Development and Research.

PCK has been considered an important construct in educational research to explore in order to improve school systems, science curricula, and teacher education and practice (Fraser, 2015). The National Science Education Standards framework (National Research Council, 1996) highlighted the importance of teachers having "opportunities to engage in analysis of the individual components of pedagogical content knowledge—science, learning, and pedagogy-and make connections between them" (p. 62).

Shulman's ideas had a foremost effect on the research community, instantly focusing attention on the importance of content knowledge in teaching and on pedagogical content knowledge in particular (Ball, 1990). Many researchers chose to focus on teacher knowledge either in context to Subject Matter Knowledge (SMK) or Pedagogical Knowledge (PK) (Gess-Newsome, 1999). SMK was primarily measured by how well teachers did on standardized tests, or how many courses they completed in a specific subject in college (Ball, 1991). SMK is considered specific scientific knowledge to provide teaching and learning in science (Friedrichsen & Dana, 2004).

SMK had been observed in a broader sense, which not only involved facts and concepts, but how well these were arranged and may influence each other. Thus, SMK is important in science teaching and affects both the content and the pedagogy (Buoni, 2012). PK is a generic form of knowledge that concerned general classroom management skills, lesson planning and student assessment. A teacher with deep PK understands the thought processes involved in student learning and construction of knowledge. PK helped the teachers to understand the cognitive, social and developmental theories of learning and how they relate to the students in the classroom (Koehler, 2009).

Since its introduction, PCK has initiated research about teacher knowledge and plays a vital role in teaching practice, effective instruction and student learning (Wu, 2013). Research studies have indicated that different features of teacher knowledge were integrated in teacher practice (Jang, 2011; Loughran, Mulhall, & Berry, 2008). Integration of PCK was achieved through continuous modifications by teachers' thinking and rethinking, and with these beliefs, the interaction between the components became stronger (Wu, 2013). Teachers' teaching practices were influenced by what they already knew and believed about teaching, learning and learners (Fraser, 2015).

A number of PCK studies have been conducted related to various subjects such as English, mathematics, science and physical education. These studies have deepened the understanding of the concept of PCK and its components. Some researchers argued that for most of the 20th century, teacher education focused on pedagogy at the expense of neglecting content knowledge (Ball & McDiarmid, 1990). Park and Oliver (2008) reviewed PCK studies and concluded that PCK was actually about how effectively teachers transmitted knowledge to students, regardless of what type of knowledge it was.

Therefore, PCK consisted of some components that were applicable to all subject areas (Wu, 2013). This study explored the PCK of GLOBE teachers using TGTQ and BARSTL and clarified their beliefs about incorporating GLOBE investigations in their classrooms.

2.6 Benefits of PCK.

PCK identified how the subject matter of a particular discipline was transferred for communication with learners. It helped the teacher to recognize what made a particular topic difficult to learn, and enabled them to help their students understand difficult math and science concepts. PCK helped teachers to come up with new teaching techniques for specific situations. To teach all students according to state standards, teachers were required to understand subject matter deeply so they could help students draw their own ideas, connect one idea to another, and re-direct their thinking to generate powerful learning. Teachers were also required to develop applicability and connect theory to everyday life. Teachers who understood subject matter deeply could help develop applications and critical thinking in students (Darling-Hammond, 1998).

2.7 Summary.

The concept of PCK is complicated because it is difficult to understand how it differs from content and pedagogy. PCK development took place in stages. PCK is dependent on trainees' capabilities to integrate knowledge from a variety of resources. It has been seen that PCK developed with time and experience and involved a variety of professional training experiences. PCK helps experienced teachers to rethink their teaching skills and new teachers to jump start their teaching techniques. Hence, from a practical point of view, SMK and PCK are both considered important for teachers, as well as for students (Buoni, 2012).

We may conclude that pedagogical knowledge is developed over time and deeply rooted in teachers' everyday work. PCK contains theoretical knowledge acquired during teaching preparation, as well as knowledge learned with practical experience. It is influenced by teachers' personal background and by the environment in which she or he works. PCK is an important component of teachers' ongoing learning and teaching core content areas. The depth of PCK determines teacher action (practice) when teaching subject matter. The PCK of a teacher enables his or her to recognize science topics that are difficult for students to learn, and to develop teaching strategies that make the concepts easier to understand.

CHAPTER III - METHODOLOGY

This study explored the teaching beliefs of GLOBE teachers with the questionnaire, Beliefs about Reformed Science Teaching and Learning (BARSTL), and investigated the influence of GLOBE training on teachers' classroom practices, scientific knowledge and student learning using the questionnaire, Teaching after Globe Training Questionnaire (TGTQ). The incorporation of both instruments provided a rich picture of the teaching beliefs and practices of GLOBE teachers. This descriptive research study helped to accurately explore teachers' perceptions and beliefs in practicing GLOBE activities and investigations in their classrooms and made comparisons between teachers who were continuing to teach with GLOBE and those who were not.

3.1 Research Design.

Using both a qualitative and a quantitative approach for this research study increases trustworthiness in the findings (Lincoln & Guba, 1985). The quantitative data was obtained from the BARSTL questionnaire. The qualitative data was obtained from the TGTQ questionnaire. Differences between the BARSTL and demographic data were analyzed.

3.2 Participants.

GLOBE-trained teachers across the U.S. were asked by GLOBE partners to participate. The participants were from K-12 and post-secondary public or private institutes. The age of the participants ranged from twenty to over sixty years. Their teaching experience ranged from one year to fifty years. After successful submission and approval by the Institutional Review Board (IRB) of The University of Southern Mississippi, data collection began.

3.3 Instrumentation.

The BARSTL and TGTQ questionnaires were used to examine the teaching beliefs and perceptions of GLOBE teachers. The details of these instruments are explained below:

The BARSTL is based on the current national science education reform movement (i.e. constructivism) and identified teachers' beliefs about teaching and learning of science (Sampson, Enderle & Grooms, 2013). It was developed by Dr. Victor Sampson, Dr. Patrick Enderle and Dr. Jonathan Grooms (2013). The BARSTL contained 32 items divided into four components: (a) How People Learn about Science (example item 1. Students develop many ideas about how the world works before they ever study about science in school); (b) Lesson Design and Implementation (example item 9. During a lesson, students should explore and conduct their own experiments with hands-on materials before the teacher discusses any scientific concepts with them); (c) Characteristics of Teachers and the Learning Environment (example item 20. The teacher should allow students to help determine the direction and the focus of a lesson); and (d) the Nature of Science Curriculum (example item 26. The science curriculum should focus on basic facts and skills of science that students will need to know later); (Sampson, Enderle & Grooms, 2013).

Each of the four components consisted of eight items with four items supporting the reformed perspective of science education and the other four supporting the traditional perspective. Participating teachers selected the degree to which they agree or disagree with each of these items using a Likert-type scale. The items that supported a reformed perspective of science education are scored as 1, 2, 3, and 4, respectively:

strongly disagree, disagree, agree, and strongly agree, and the items that indicated a traditional perspective were scored in reverse. Therefore, the possible scores ranged from 32 to 128 points. Therefore, higher scores indicated teachers' beliefs are more aligned with constructivism (Sampson, Enderle & Jonathon, 2013).

The TGTQ was prepared to examine the experiences of GLOBE teachers during classroom practices. It was prepared under the guidance of Dr. Sherry Herron, who is the GLOBE partner for Mississippi and an active member of the GLOBE North American Partner Forum. Dr. Herron, who is also the Director for Center of Science and Mathematics Education in the University of Southern Mississippi, is well-informed in the area of science education, as well as in conducting GLOBE activities. The GLOBE program is aligned with the National Science Education Standards and supports both science and education with emphasis on teacher preparation and professional development (Penuel et al., 2007). The TGTQ was compiled with the GLOBE Program in mind and consists of open-ended questions concerning GLOBE teachers and pedagogy. The TGTQ contained five demographic items and eighteen short questions pertaining to GLOBE teachers' teaching practices. The demographic items helped to explore, compare and contrast teachers' beliefs in teaching and learning science with respect to different demographics. These included state, age, and grade level of students taught, subjects taught, type of institute (public or private) taught in, years of teaching experience, and the GLOBE protocols (Atmosphere, Earth as a System, Hydrology, Land Cover/Biology and Soil) in which they were trained.

The open-ended questions in TGTQ provided answers to eight qualitative research questions. TGTQ provided valid information explaining the influence of

GLOBE training on teachers' scientific knowledge and teaching. For example, question No. 3 asked the participants to explain how GLOBE training impacted their scientific knowledge; the responses to TGTQ gave a clear picture of the struggles and accomplishments that GLOBE teachers came across while implementing GLOBE activities and protocols along with data entry. Questions No. 13 and 14 asked participants to explain what kind of struggles and successes they had in teaching GLOBE activities, collecting data, and analyzing and uploading data to the GLOBE website or other. TGTQ responses disclosed teaching strategies that teachers adapted to improve science teaching and learning, including STEM (Science, Technology, Engineering and Mathematics) Education. For example, No.16 asked how the participant implemented GLOBE activities to enrich STEM education in class. In addition, No.17 asked how they convinced others teaching any science or STEM course to use the GLOBE program. TGTQ provided insight into teachers' beliefs concerning their future plans in GLOBE teaching. For example, No.18 asked whether the participant planned to continue using GLOBE activities and protocols. Overall, TGTQ helped identify the successes and barriers in integrating GLOBE activities into classroom practices.

3.4 Procedure.

Permission to conduct this research was requested from the University of Southern Mississippi's Institutional Review Board. The BARSTL and TGTQ were placed on a website known as Qualtrics so that GLOBE teachers had easy access to it [see Appendices A & B for the copies of TGTQ and BARSTL]. Qualtrics is a sophisticated and user-friendly web-based software for administering surveys online. It is a secure system for data collection and made the review of answers easy. Qualtrics leads academic survey research and is commonly used in most colleges and universities (Carr, 2013).

Upon approval from IRB, Dr. Herron sent an email to GLOBE Partners with a request and asked all trained GLOBE teachers in their area to participate in our research. The Partners sent a link to the BARSTL and TGTQ questionnaires to their teachers. The BARSTL and TGTQ questionnaires were administered online using Qualtrics to ensure anonymity. Teachers who did not respond were effectively not giving their consent. There was no penalty for a teacher's lack of participation, and anonymity was retained for all respondents throughout the process.

Both questionnaires remained open for three months to provide enough time for teachers to respond. Data was collected from the Qualtrics site itself, and permanently deleted after the close of this research. As an incentive, a $50 Amazon gift card was given to one participating GLOBE partner with the highest number of member teacher participants and a $50 Amazon gift card was sent to one teacher who completed the questionnaires. In order to protect anonymity, a link to a separate website was provided at the end of the questionnaire. Participants went to that website in order to register for the drawing. The name of the winning participating teacher was selected through a drawing using a random number generator.

3.5 Data Analysis.

A quantitative analysis of the survey was used to address both descriptive and statistical questions. Qualitative analysis was used to examine teachers' experiences with GLOBE and what teachers personally believed were their perceptions about teaching with

GLOBE. Qualitative and quantitative responses both from typical representatives of the population, as well as outliers, were examined to give a broad base for analysis.

Descriptive analysis was used to address the following research questions:

- Where do GLOBE teachers lie on the BARSTL continuum (the total score of BARSTL)?
- Where do GLOBE teachers lie on individual BARSTL components (how people learn about science, lesson design and implementation, characteristics of teachers and the environment, the nature of science curriculum)?

Statistical analysis was used to address the following research questions using data from the BARSTL and TGTQ:

- Is there a significant difference between the total BARSTL score and number of years these teachers have been teaching?
- Is there a significant difference between each of the 4 component scores of the BARSTL and the number of years these teachers have been teaching?
- Is there a significant difference between the total BARSTL scores and age the teachers?
- Is there a significant difference between each of the 4 component scores of the BARSTL and the age of the teachers?
- Is there a significant difference between the total BARSTL scores and the region where these teachers have taught?
- Is there a significant difference between each of the 4 component scores of the BARSTL and the regions in which they been teaching?

Qualitative analysis was used to address the following research questions using the TGTQ:

- How do GLOBE teachers integrate GLOBE protocols and investigations into their classroom practices? Question 1, 2, 4, 5, 7, 8, 9, 11, 12, and 18
- Why do teachers integrate GLOBE activities in their teaching? Question 6
- How do teachers implement GLOBE activities to enrich STEM education in class? Question 16 and 17
- What types of challenges do teachers report implementing GLOBE investigations into classroom practices? Question 13a, 13b, 13c, 13d and 13e
- What kind of successes do teachers experience during implementing GLOBE activities? Question 14a, 14b, 14c, 14d and 14e
- In what way has GLOBE training influenced teachers' scientific knowledge? Question 3
- How do GLOBE teachers believe GLOBE involvement in the classroom influences their students' learning? Question 10 and 15
- How do teachers change their teaching strategies after learning GLOBE? Question 4

Data was initially analyzed using descriptive statistics and frequency analysis of the BARSTL questionnaire. Statistical questions were then analyzed using demographic data from TGTQ including age of teachers, number of years of teaching experience, type of GLOBE investigation trained in, grade level of students, subject taught, and state and institute (private or public) where they taught. A one-way ANOVA provided the differences between the demographics (the independent variables) and each of the total

BARSTL and the four BARSTL sub-score (the dependent variables). This resulted in five ANOVAs with the same independent variables, with separate dependent variables. Then they were analyzed and compared to find out if there were any differences and in what independent variables were significant predictors. Mean BARSTL scores for GLOBE teachers who continued implementing GLOBE and who discontinued practicing GLOBE in classroom teaching were also calculated and analyzed.

Qualitatively, data was collected by coding the responses to open-ended questions, and then further investigated to observe repetitive and common themes that emerged from the open-ended answers of participants. The repetition of the quantitative steps as explained in this chapter, also increased the validity of data analysis. This descriptive research study, consisting both quantitative and qualitative analysis increased the conformability of data (Lincoln & Guba, 1985).

CHAPTER IV –RESULTS

The overall purpose of this dissertation was to explore the teaching beliefs of GLOBE (Global Learning and Observations to Benefit the Environment) teachers, and to analyze their pedagogical practices. This was accomplished by using a descriptive research approach. Quantitatively, the pedagogical beliefs of GLOBE teachers were measured using the Beliefs about Reformed Science Teaching and Learning (BARSTL) questionnaire. Qualitatively, their teaching experiences were investigated with their responses from open-ended questions in an instrument referred to as the Teaching after Globe Training Questionnaire (TGTQ). Together, these instruments provided results to understand the influence of GLOBE training on teachers' teaching beliefs with respect to different demographics. The results showed where GLOBE teachers fell on the BARSTL continuum - from traditional to constructivist beliefs. It also helped to understand the connection between pedagogy and beliefs. The results explained how some GLOBE teachers modified their classroom teaching practices and continued using GLOBE while others discontinued. This study will help GLOBE trainers to better understand the challenges that teachers with traditional teaching beliefs may have with implementation of GLOBE in their classrooms.

The data was collected from trained GLOBE teachers across the U.S. using Qualtrics.com. The link to the instruments was emailed to GLOBE partners who then distributed it to the teachers in their regions. Seventy-four teachers participated, but two teachers were not GLOBE trained. Therefore, 72 responses were included in the study. Criteria for inclusion in the study were that the questionnaires needed to be over 75% complete, with no more than 25% missing from any subscale area of the BARSTL.

Essentially, this meant that respondents skipped/marked no response to no more than two questions in each of the four BARSTL subscales. The survey link was left open for three months. Even though the number of responses did not meet expectations for power, the decision was made to proceed with data analysis.

As shown in Table 4.1, respondents from five GLOBE regions: Northwest (Alaska, Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, South Dakota, Nebraska), Southwest (Utah, Arizona, New Mexico, Colorado, Kansas, Oklahoma, Texas) , Midwest (Minnesota, Iowa, Missouri, Wisconsin, Michigan, Illinois, Indiana, Ohio), Southeast (Arkansas, Louisiana, Kentucky, Tennessee, Mississippi, Alabama, North Carolina, South Carolina, Georgia, Florida), Northeast and Mid-Atlantic (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Delaware, Maryland, D.C., West Virginia, Virginia) participated. Thirteen (18%) participants from Northwest (NW), 10 (14%) from Southwest (SW), 5 (7%) from Midwest (MW), 32 (44%), from Southeast (SE), and 12 (17%) from Northeast and Mid-Atlantic completed the questionnaire.

Table 4.1 *Frequency Statistics by Region*

	Frequency	Percentage
Northwest	13	18.06
Southwest	10	13.89
Midwest	5	6.94
Southeast	32	44.44
Northeast & Mid-Atlantic	12	16.67
Total	72	100.0

Data was collected from both public and private institutions. As shown below in Table 4.2, 66 (92%) respondents were from public institutions, 5 (7%) were from private institutions and only 1 (1%) home schooled.

Table 4.2 *Frequency Statistics by Type of Institution*

	Frequency	Percentage
Public	66	91.67
Private	5	6.94
Home school	1	1.39
Total	72	100.0

The age of participating teachers ranged widely. As shown in Table 4.3, 20 (28%) respondents were between 20-40 years, 22 (31%) were between 41-50 years, 19 (27%) were between 51-60 years and 10 (14%) were above 60 years of age.

Table 4.3 *Frequency Statistics by Age*

	Frequency	Percentage
20-40 years	20	28.17
41-50 years	22	30.99
51-60 years	19	26.76
Above 60 years	10	14.08
Total	71	100.0

The teaching experience of respondents is shown below in Table 4.4 Nineteen (28%) participants had experience of 1-10 years, 23 (34%) had 11-20 years of experience, 15 (22%) had 21-30 years of experience, and 11 (16%) had 31-50 years of experience.

Table 4.4 *Frequency Statistics by Experience*

	Frequency	Percentage
1-10 years	19	27.94
11-20 years	23	33.82
21-30 years	15	22.06
31-50 years	11	16.18
Total	68	100.0

As shown in Table 4.5, both K-12 and post-secondary teachers were participants: 7 (10%) teachers taught all K-12 grades, 36 (50%) teachers were from high school, 7 (10%) were from middle, 10 (14%) were from elementary, 8 (11%) were from college/university, and 4 (5%) teachers taught in both school and college.

Table 4.5 *Frequency Statistics by Teaching Grade*

	Frequency	Percentage
All (K-12)	7	9.72
High School	36	50.00
Middle School	7	9.72
Elementary School	10	13.89
College/University	8	11.11
Both (College/School)	4	5.56
Total	72	100.0

4.2 Quantitative Analysis.

The pedagogical beliefs of GLOBE teachers were measured using the Beliefs about Reformed Science Teaching and Learning (BARSTL) questionnaire. Based on factor analysis and validity tests of the subscales, BARSTL was found to be a valid instrument in assessing pedagogical content beliefs. A split-half coefficient expressed as a Spearman-Brown corrected correlation and coefficient alpha (.80 and .77 respectively) reveals it to be a reliable instrument (Sampson, Enderle & Jonathon, 2013).

The quantitative analysis was done to measure the teaching beliefs of GLOBE teachers using a one-way ANOVA in SPSS. The demographics included multiple groups, so ANOVAs were used rather than t-tests in order to control for Type I error. Necessary follow-up analysis, including post hoc tests, were done where significance was found.

4.3 Details of BARSTL.

The BARSTL questionnaire was administered to the respondents to measure their placement on the continuum of teaching beliefs. This questionnaire consisted of four components: How People Learn about Science, Lesson Design and Implementation, Characteristics of Teachers and the Learning Environment, and The Nature of the Science Curriculum. Each component had eight questions consisting of four constructive and four traditional items. In component one, How People Learn about Science, Items 1, 2, 5, and 8 are constructivist, and Items 3, 4, 6, and 7 are traditional. In component 2, Lesson Design and Implementation, Items 9, 10, 13, and 14 are constructivist, and Items 11, 12, 15, and 16 are traditional. In component 3, Characteristics of Teachers and the Learning Environment, Items 17, 19, 20, and 24 are constructivist, and Items 18, 21, 22, and 23 are traditional. In component 4, the Nature of Science Curriculum, Items 25, 28, 30 and 32 are constructivist, and Items 26, 27, 29, and 31 are traditional. The participating teachers answered each question by selecting agreed or disagreed, which was measured using a Likert-type scale. The constructivist items were scored as 1 for strongly disagree, 2 for disagree, 3 for agree, and 4 for strongly agree. The traditional items were scored in reverse with 4 for strongly disagree, 3 for disagree, 2 for agree, and 1 for strongly agree. Therefore, the BARSTL component scores can range from 8 to 32 and the total score from 32 to 128 points. Representing a continuum, scores less than 80 align with traditional beliefs and scores greater than 80 align with constructivist beliefs. A score of 80 represents teaching beliefs that contain elements of both traditional and constructivist (Sampson, Enderle & Jonathon, 2013).

4.4 Descriptive Analysis.

Descriptive analysis was used to address the following research questions:

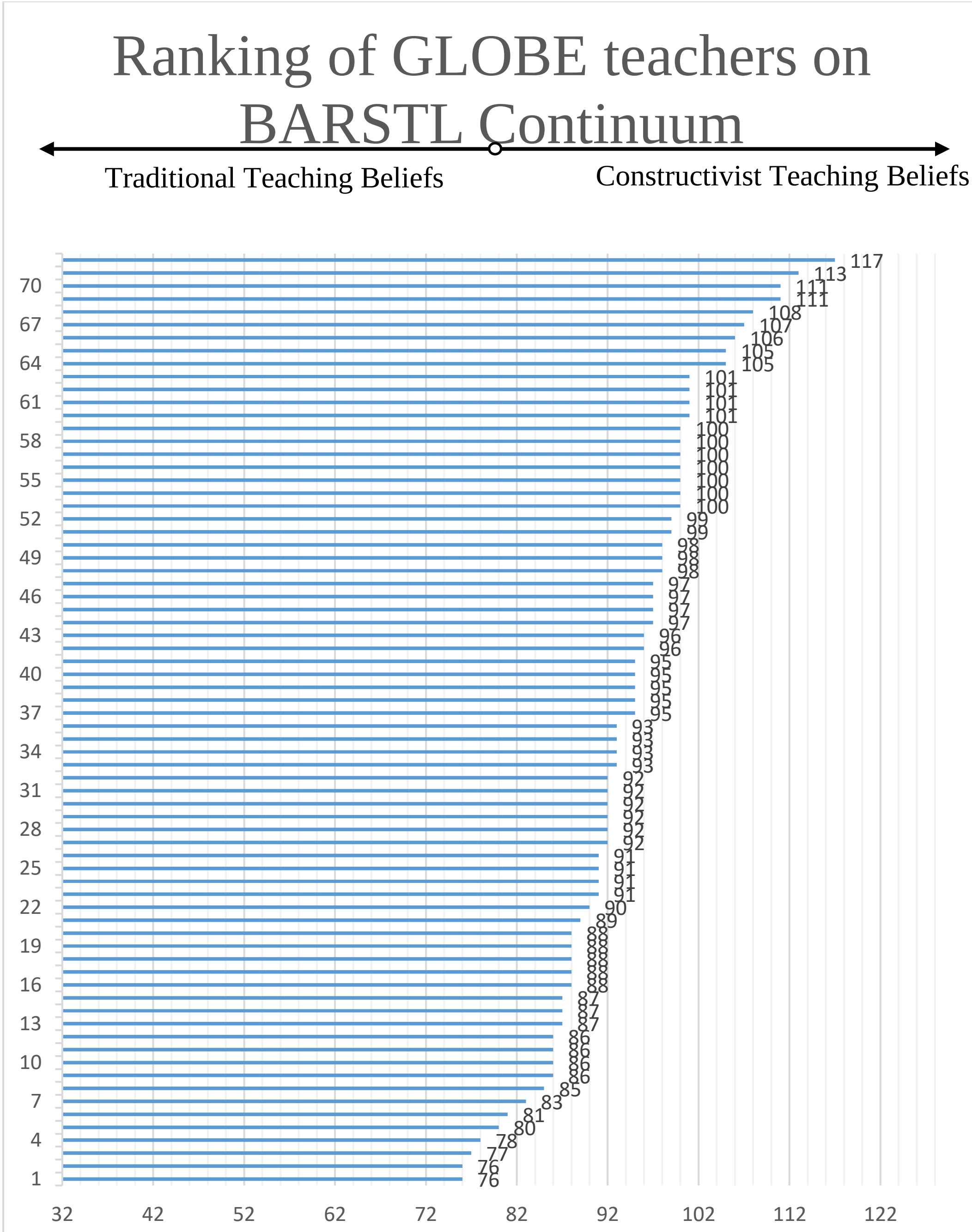
- Where do GLOBE teachers lie on the BARSTL continuum (the total score of BARSTL)?
- Where do GLOBE teachers lie on individual BARSTL components (how people learn about science, lesson design and implementation, characteristics of teachers and the environment, the nature of science curriculum)?

The mean scores as shown in table 4.6 provide answers to these two descriptive questions. The descriptive statistics of overall BARSTL scores is shown in table 4.6, the mean total BARSTL score for tested group (N = 72) was 94.31. The minimum of the total BARSTL score was 76 and the maximum score was 117. The mean BARSTL score for component one, How People Learn about Science, was 22.56 (minimum17, maximum 29). The mean BARSTL score for component two, Lesson Design and Implementation, was 23.88 (minimum 17, maximum 29). The mean BARSTL score for component three, Characteristics of Teachers and the Learning Environment, was 24.64 (minimum 18, maximum 31). The mean BARSTL score for component four, the Nature of the Science Curriculum, was 23.24 (minimum18, maximum 31).

The mean scores of each component were greater than 20 out of 32, revealing that the GLOBE teachers held more constructive teaching beliefs than traditional ones. The total mean score was more than 80 out of 128, again revealing that most of the GLOBE teachers were aligned towards constructivist teaching beliefs. Figure 4.1 shows the 72 teachers' total BARSTL scores in rank order. On the top of this figure, a line with a clear dot at 80, signifies the dividing line between constructivist and traditional teaching beliefs. Only four teachers held traditional teaching beliefs (76 – 78), one held a balanced teaching belief (80), and the remaining 67 teachers held constructivist teaching beliefs (81-117). However, 76 is very close to 80, which means that these four were close to balanced.

Table 4.6 *Mean Scores of Total BARSTL and the four Components*

BARSTL Score	Minimum	Maximum	Mean
Total BARSTL Scores	76	117	94.31
Component 1	17	29	22.56
Component 2	17	29	23.88
Component 3	18	31	24.64
Component 4	18	31	23.24
Total (N)	72		



Total BARSTL scores

Figure 4.1 Ranking of GLOBE teachers and their total BARSTL scores.

Ranking of GLOBE teachers on BARSTL continuum with total BARSTL scores on x-axis and participants on y-axis.

One interesting fact to note is that both skewness and kurtosis for the overall BARSTL score, as shown in table 4.7 and in figure 4., the histogram was moderate, meaning that the BARSTL score was close to a normal distribution.

Table 4.7 *Descriptive Statistics for Overall BARSTL score.*

		OVERALL BARSTL SCORE
N	Valid	72
	Missing	4
Mean		94.31
Median		94
Std. Deviation		8.471
Variance		71.764
Skewness		.215
Kurtosis		.133
Minimum		76
Maximum		117

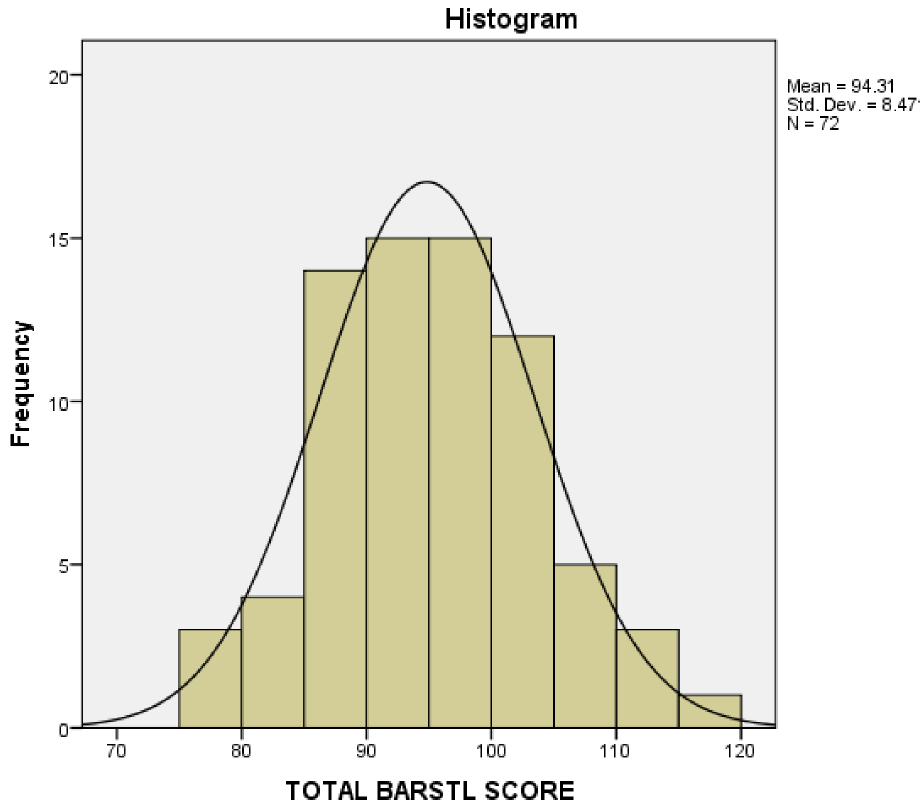


Figure 4.2 Histogram for Overall BARSTL Score.

The histogram is moderate and close to normal distribution as shown in the above the figure.

4.5 Statistical Analyses.

Statistical analysis was used to address the differences between the demographics and each of the total BARSTL scores and the BARSTL scores for the four components. Demographic data from the TGTQ, including the number of years of teaching experience, age of teachers, region, and the institute (private or public) where they teach and the BARSTL scores were analyzed and compared to find out if there were any significant differences, and which independent variable was a significant predictor. In this study, there were a very few number of respondents from private institutes, so, this independent variable (institute) was not further analyzed. A one-way ANOVA was run to analyze each of the remaining demographic variables with total BARSTL scores and the BARSTL scores from four components using SPSS, which resulted in five ANOVAs for each variable. The following research questions were statistically analyzed using data from the BARSTL and TGTQ. To study the differences between the total BARSTL scores and the number of years of teaching experience of teachers, the following question was studied.

- Is there a significant difference between the total BARSTL score and the number of years these teachers have taught?

A one-way ANOVA was performed to determine if there was a significant difference between the total BARSTL score and number of years of teaching experience of GLOBE teachers. The one-way ANOVA result, F (3, 64) =1.799, p=.156, $\alpha = .05$, showed that there was no significant difference between the total BARSTL score and number of years these teachers have taught. Table 4.8 shows the frequency data of mean scores of total BARSTL and number of years taught.

Table 4.8 *Frequency Data showing the Mean Score of the Total BARSTL and the number of years taught.*

Teaching Experience	Frequency	Mean Score
1-10 years	19	92.16
11-20 years	23	95.04
21-30 years	15	98.40
31-50 years	11	92.36
Total	68	94.54

The analysis of the BARSTL scores for all four components and the number of years of GLOBE teachers was performed to answer the following question:

- Is there a significant difference between the BARSTL scores for each of the four components and the number of years these teachers have been teaching?

A one-way ANOVA was performed to see if there were any significant differences between the BARSTL score of How People Learn about Science (component 1) and the number of years of teaching experience of GLOBE teachers. The result of a one-way ANOVA, F (4, 63) =1.414, p=.240, $\alpha = .05$, showed that there was no significant difference between the BARSTL score for component 1 and the number of years these teachers have taught. Table 4.9 shows the frequency data of the mean BARSTL scores for component 1 and the number of years taught.

Table 4.9 *Frequency Data showing the Mean BARSTL Score for Component 1 and the number of years taught*

Teaching Experience	Frequency	Mean Score
1-10 years	19	22.21
11-20 years	23	22.13
21-30 years	15	23.67
31-40 years	9	22.44
41-50 years	2	25.00
Total	68	23.09

In order to determine if there was a significant difference between the BARSTL scores for the Lesson Design and Implementation (component 2) and the number of years of teaching experience of GLOBE teachers, a one-way ANOVA was performed. The result, showing F (4, 63) =1.117, p=.357, $\alpha = .05$, showed that there was no significance found between the BARSTL scores for component 2 and the number of years of teaching experience. Table 4.10 shows the frequency data of the mean BARSTL score for component 2 and the number of years teaching experience of GLOBE teachers.

Table 4.10 *Frequency Data showing Mean BARSTL Score for component 2 and the number of years taught*

Teaching Experience	Frequency	Mean Score
1-10 years	19	23.11
11-20 years	23	24.13
21-30 years	15	24.93
31-40 years	9	23.33
41-50 years	2	24.00
Total	68	23.91

To study if there was a significant difference between the BARSTL scores for the Characteristics of Teachers and the Learning Environment (component 3) and the number of years of teaching experience of GLOBE teachers, a one-way ANOVA was performed. The result, F (4, 63) =1.169, p=.333, $\alpha = .05$, showed that there was no significance found between the BARSTL scores for component 3 and the number of years of teaching experience. Table 4.11 shows the frequency data of the mean BARSTL scores for component 3 and the number of years taught.

Table 4.11 *Frequency Data showing Mean BARSTL Scores for Component 3 and the number of years taught*

Teaching Experience	Frequency	Mean Score
1-10 years	19	24.37
11-20 years	23	25.30
21-30 years	15	25.07
31-40 years	9	23.00
41-50 years	2	24.50
Total	68	24.50

To analyze if there was a significant difference between the BARSTL scores for the Nature of Science Curriculum (component 4) and the number of years of teaching experience of GLOBE teachers, a one-way ANOVA was performed. The result, F (4, 63) =1.755, p=.149, $\alpha = .05$, showed that there was no significance found between the BARSTL scores for component 4 and the number of years of teaching experience. Table 4.12 shows the frequency data of mean score of BARSTL 4 and number of years taught.

Table 4.12 *Frequency Data showing Mean BARSTL Score for Component 4 and the number of years taught*

Teaching Experience	Frequency	Mean Score
1-10 years	19	22.47
11-20 years	23	23.48
21-30 years	15	24.73
31-40 years	9	22.78
41-50 years	2	22.50
Total	68	23.20

Hence, there was no significance found between the BARSTL scores for all four components and the number of years of teaching experience. The assumptions for HOV were met. To study the differences between total BARSTL scores and the age of teachers, the following question was analyzed.

- Is there a significant difference between the total BARSTL score and the age of teachers?

To analyze if there was a significant difference between the total BARSTL score and the age of GLOBE teachers, one-way ANOVA was performed. The result, F (3, 67) =.964, p=.415, $\alpha = .05$, showed that there was no significance found between the total BARSTL score and the age of teachers. Table 4.13 shows the frequency data of the mean score of total BARSTL scores and the age of teachers.

Table 4.13 *Frequency Data showing the Mean Total BARSTL Score and the Age of Teachers*

Age of Teachers	Frequency	Mean Score
20-40 years	20	92.85
41-50 years	22	96.86
51-60 years	19	93.68
60+ years	10	93.00
Total	71	94.34

The analysis of the BARSTL scores for all four components and the age of GLOBE teachers was performed to answer the following question:

- Is there a significant difference between the BARSTL scores for each of the four components and the age of these teachers?

A one-way ANOVA was performed to see if there was a significant difference between the BARSTL scores of how people learn about science (component 1) and the age of GLOBE teachers. The result, F (3, 67) =.435, p=.729, $\alpha = .05$, showed that there was no significant difference between the BARSTL score for component 1 and the age of these teachers. Table 4.14 shows the frequency data of mean score of BARSTL 1 and the age of GLOBE teachers.

Table 4.14 *Frequency Data showing the Mean BARSTL Score for Component 1 and the Age*

Age of Teachers	Frequency	Mean Score
20-40 years	20	22.25
41-50 years	22	22.82
51-60 years	19	22.21
60+ years	10	23.10
Total	71	22.54

In order to see if there was a significant difference between the BARSTL scores for the lesson design and implementation (component 2) and the age of GLOBE teachers, a one-way ANOVA was performed. The result, F (3, 67) =1.33, p=.271, $\alpha = .05$ showed that there was no significance found between the BARSTL scores for component 2 and the age of GLOBE teachers. Table 4.15 shows the frequency data of mean BARSTL score for component 2 and the age of GLOBE teachers.

Table 4.15 *Frequency Data showing Mean BARSTL Score for Component 2 and the Age*

Age of Teachers	Frequency	Mean Score
20-40 years	20	23.40
41-50 years	22	24.82
51-60 years	19	23.53
60+ years	10	23.50
Total	71	23.89

To study if there was a significant difference between the BARSTL score for the characteristics of teachers and the learning environment (component 3) and the age of GLOBE teachers, a one-way ANOVA was performed. The result, F (3, 67) =2.278, p=.088, $\alpha = .05$ showed that there was no significant difference found between BARSTL scores of component 3 and the age of GLOBE teachers. The p value of .088, however, is approaching statistical significance. This result may be due to the small sample size. Table 4.16 shows the frequency data of the mean BARSTL score for component 3 and the age of teachers.

Table 4.16 *Frequency Data showing the Mean BARSTL Score for Component 3 and the Age*

Age of Teachers	Frequency	Mean Score
20-40 years	20	24.55
41-50 years	22	25.68
51-60 years	19	24.58
60+ years	10	23.00
Total	71	24.69

To analyze if there was a significant difference between the BARSTL score for the nature of science curriculum (component 4) and the age of GLOBE teachers, a one-way ANOVA was performed. The result, F (3, 67) =.422, p=.738, $\alpha = .05$, showed that there was no significance found between the BARSTL score for component 4 and the age of GLOBE teachers. Table 4.17 shows the frequency data of mean BARSTL score for component 4 and the age of teachers.

Table 4.17 *Frequency Data showing Mean BARSTL Score for Component 4 and the Age*

Age of Teachers	Frequency	Mean Score
20-40 years	20	22.65
41-50 years	22	23.55
51-60 years	19	23.37
60+ years	10	23.40
Total	71	23.23

Hence, there was no significance found between the BARSTL scores for all four components and the age of teachers. The assumption for HOV was met.

To study the differences between the total BARSTL scores and the region where the GLOBE teachers teach, the following question was analyzed:

- Is there a significant difference between the total BARSTL score and the regions where the GLOBE teachers teach?

To analyze if there was a significant difference between the total BARSTL scores and the regions where the GLOBE teachers teach, a one-way ANOVA was performed. Since there were a few respondents from NE, MW, SW and NW regions, these were combined together as one group for ANOVA. The one-way ANOVA result, F (1, 66) =3.995, p=.05, $\alpha = .05$, showed that there was a significant difference between the total BARSTL scores and the regions. The assumption for HOV was met. Table 4.18 shows the frequency data of the mean BARSTL scores and the regions where teachers teach. Post hoc tests were not performed for the total BARSTL scores and the regions because there were fewer than three groups.

Table 4.18 *Frequency Data showing the Mean Scores of the Total BARSTL Scores and the Region*

Region of Teachers	Frequency	Mean Score
Other	38	96.29
Southeast	32	92.28
Total	70	94.46

The analysis of the BARSTL scores for four components and the regions where GLOBE teachers teach was performed to answer the following question:

- Is there a significant difference between each of the BARSTL scores for the four components and the regions where GLOBE teachers teach?

A one-way ANOVA was performed to see if there was a significant difference between the BARSTL scores for How People Learn about Science (component 1) and the regions where GLOBE teachers teach. The result of the one-way ANOVA, F (1, 68) =.3.251, p=.076, $\alpha = .05$, showed that there was no significant difference between the BARSTL scores for component 1 and the regions where GLOBE teachers teach. The p value of .076, however, is approaching statistical significance. This result may be due to a small sample size and unbalanced distribution of sample in each region. In our data, one region had many participants while other regions had relatively few. As shown in table 1.1, most of the participants were from the SE region (44.44%), the least number of participants from the MW region (6.94%) and very few participants from the SW region (13.89%), the NE region (16.67%) and the NW region (18.06%). Therefore, the regions with fewest and the least number of participants were grouped together as one region. Table 4.19 shows the frequency data of mean score of BARSTL 1 and SE regions and other regions, where GLOBE teachers teach.

Table 4.19 *Frequency Data showing the Mean BARSTL Score for Component 1 and the Region*

Region of Teachers	Frequency	Mean Score
Other	38	23.05
Southeast	32	21.97
Total	70	22.56

In order to see if there was a significant difference between the BARSTL scores for Lesson Design and Implementation (component 2) and the regions where GLOBE teachers teach, a one-way ANOVA was performed. The result, F (1, 68) =.569, p=.453, $\alpha = .05$ showed that there was no significance found between the BARSTL scores for component 2 and the region where GLOBE teachers teach. Table 4.20 shows the frequency data of mean BARSTL score for component 2 and the region where GLOBE teachers teach.

Table 4.20 *Frequency Data showing the Mean BARSTL Score for Component 2 and the Region*

Region of Teachers	Frequency	Mean Score
Other	38	24.08
Southeast	32	23.59
Total	70	23.86

To determine if there was a significant difference between the BARSTL scores for the Characteristics of Teachers and the Learning Environment (component 3) and the region where GLOBE teachers teach, a one-way ANOVA was performed. The result, F (1, 68) =1.956, p=.166, $\alpha = .05$, showed that there was no significance found between the BARSTL scores for component 3 and the region where GLOBE teachers teach. Table 4.21 shows the frequency data of the mean BARSTL score for component 3 and the region where GLOBE teachers teach.

Table 4.21 *Frequency Data showing Mean BARSTL Score and the Region*

Region of Teachers	Frequency	Mean Score
Other	38	25.11
Southeast	32	24.16
Total	70	24.67

To analyze if there was a significant difference between the BARSTL scores for the Nature of Science Curriculum (component 4) and the region where GLOBE teachers teach, a one-way ANOVA was performed. The result, F (1, 68) =6.075, p=.016, $\alpha = .05$, showed that there was a significant difference between BARSTL scores for component 4 and the regions where teachers teach. The assumption for HOV was met. Table 4.22 shows the frequency data of mean BARSTL scores for component 4 and the region where teachers teach. Post hoc tests were not performed for the BARSTL scores for component 4 and the regions because there are fewer than three groups.

Table 4.22 *Frequency Data showing Mean BARSTL Score for Component 4 and the Region*

Region of Teachers	Frequency	Mean Score
Other	38	24.05
Southeast	32	22.56
Total	70	23.37

The results of the one-way ANOVA showed that there was no significance found in BARSTL scores for three components (1, 2 & 3) and the region in which GLOBE teachers teach. However, there was a significance difference found between the BARSTL scores for component 4 and the regions where GLOBE teachers teach.

4.6 Qualitative Analysis.

Qualitative analysis was performed to study the teaching practices of GLOBE teachers using the Teaching with GLOBE after Training Questionnaire (TGTQ) which consisted of 7 demographic items and 18 items with both forced choice and open-ended questions. The following are the results from the TGTQ.

1. After being trained in GLOBE, estimate your level of use in your classroom:

Sixty-seven teachers responded this item, out of which 30 participants (44.78%) use GLOBE occasionally, 25 participants (37.31%) use GLOBE frequently and 12 participants (17.91%) sometimes use GLOBE in their classroom as shown in figure 4.3.

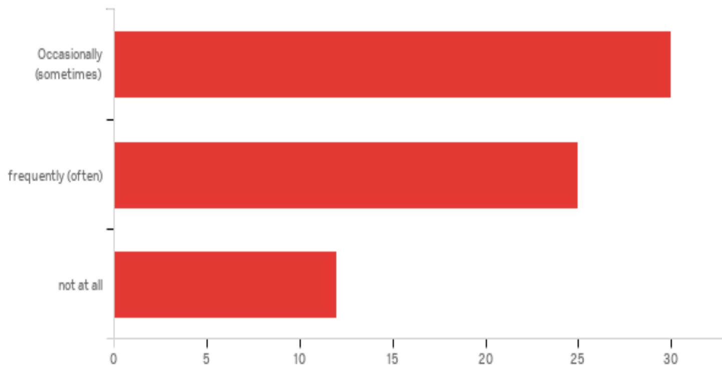


Figure 4.3 Frequency of level of use of GLOBE in classroom practice.

2. Have you stopped using GLOBE in the courses you teach?

Sixty-seven teachers responded to this item, out of which 19 teachers (28.36 %) have stopped using GLOBE whereas 48 teachers (71.64%) have not stopped using it in the courses they teach as shown in figure 4.4.

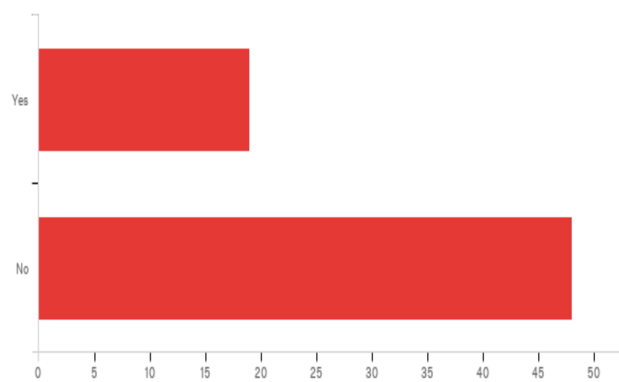


Figure 4.4 Frequency of teachers who have stopped using GLOBE in classroom practice.

3. Did you change your teaching strategies after learning GLOBE protocols or activities?

Sixty-four teachers responded to this item, out of which 39 teachers (60.94%) changed their teaching strategies, and 25 teachers (39.06%) did not change their teaching strategies after learning GLOBE activities, represented in figure 4.5.

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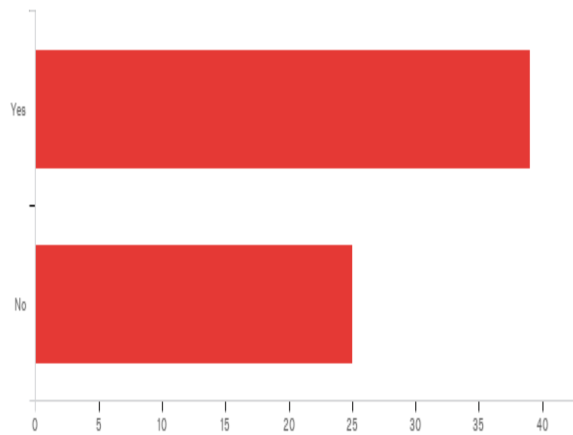

Figure 4.5 Frequency of teachers who have changed their teaching strategies after learning GLOBE activities

4. How long have you been using GLOBE activities/protocols in class?

Sixty-four teachers responded to this item as shown in figure 4.6. It was found that 18 teachers (28.13%) have been using GLOBE activities/protocols <1 year, 9 teachers (14.06%) have been using GLOBE 1 to 2 years, 13 teachers (20.31%) have been using GLOBE 3 to 5 years, 5 teachers (7.81%) have been using GLOBE 5 to 10 years and 19 teachers have been using GLOBE >10 years.

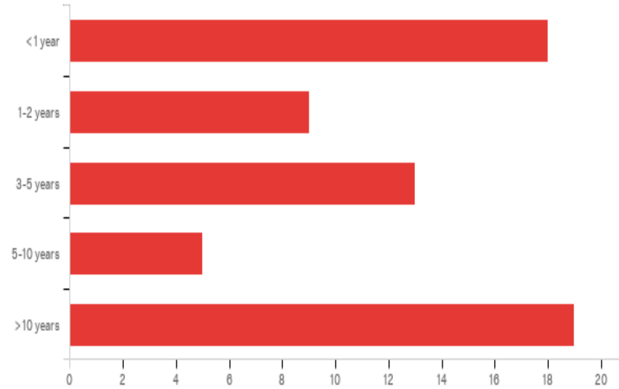

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Figure 4.6 Frequency of teachers showing the number of years they have been using GLOBE activities/protocols in class.

5. In approximately how many lessons do you incorporate GLOBE activities during a course?

Sixty-one respondents answered this item, out of which 24 teachers (39.34%) reported that they incorporate 1 to 2 lessons, 13 teachers (21.31%) incorporate 2 to 4 lessons, 7 teachers (11.48%) incorporate 4 to 6 lessons, 3 teachers (4.92%) incorporate 6 to 8 lesssons, 1 teacher (1.64%) incorporates 8 to 10 lessons, and 13 teachers (21.31%) incorporate 10 or more lessons during a course. Figure 4.7 shows the graphic representation of this item.

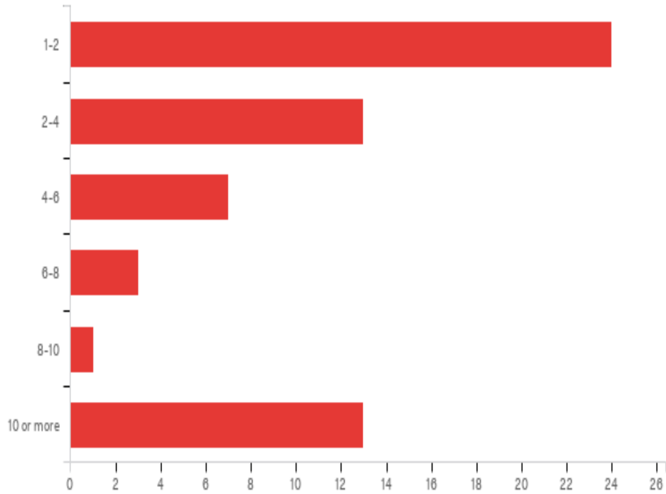

Figure 4.7 Frequency of teachers showing how many lessons they incorporate GLOBE

6. Do you believe that teaching with GLOBE has influenced your students' learning?

Fifty-eight teachers answered this question, out of which 52 teachers (89.66%) believed that GLOBE has influenced their students' learning and 6 teachers (10.34%) did not, as shown in figure 4.8.

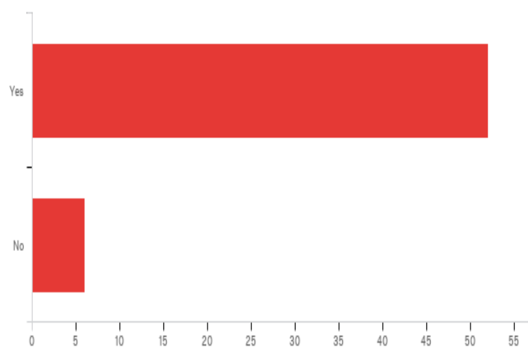

Figure 4.8 Frequency of teachers who believe that teaching with GLOBE has influenced their students' learning

7. Would you like to implement more outdoor or indoor GLOBE activities?

Fifty-nine teachers responded this item, out of which only 17 teachers (28.81%) liked to implement more indoor activities and 42 teachers (71.19%) liked to implement more outdoor activities, as shown in figure 4.9.

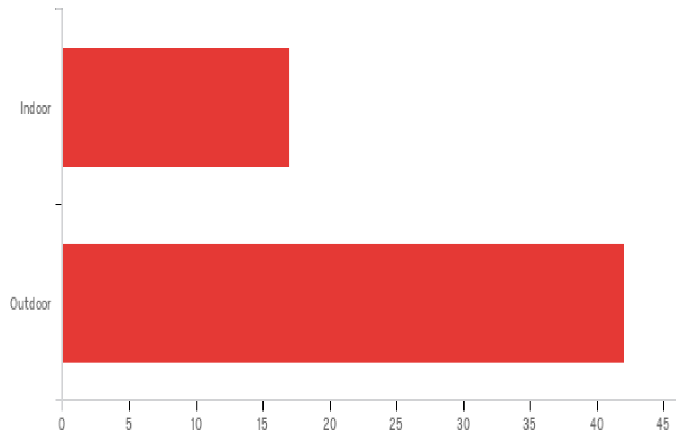

Figure 4.9 Frequency of teachers who liked to implement more indoor or outdoor GLOBE activities.

8. How often do you or your students enter data on the GLOBE website?

Forty-eight teachers answered this item, out of which 31 teachers (64.58%) entered data one time every grading unit, 6 teachers (12.5%) entered data two times, 2 teachers (4.17%) entered data three times, and 9 teachers (18.75%) entered data more than three times every grading unit, as shown in figure 4.10.

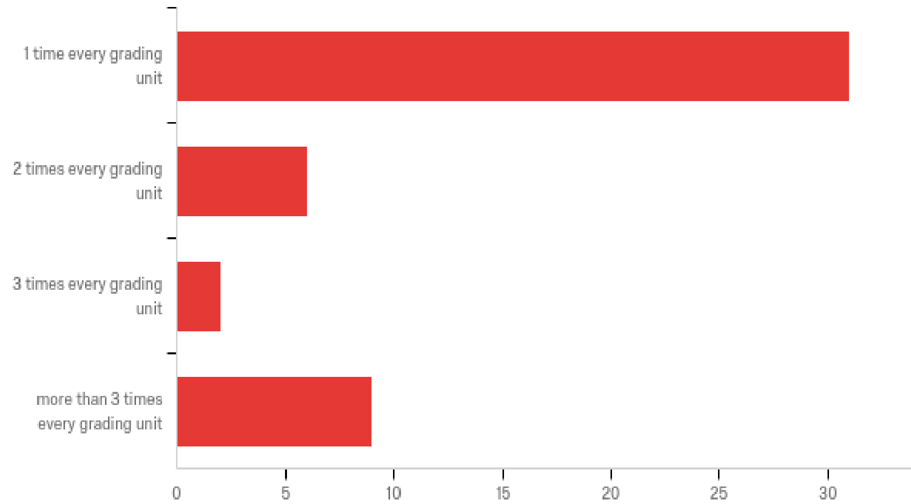

Figure 4.10 Frequency of teachers who enter data on the GLOBE website.

9. Do accelerated or regular students learn better with GLOBE investigations?

Fifty-six teachers responded to this item, out of which 54 teachers (96.43%) thought both regular and accelerated students learn better with GLOBE investigations. Only one teacher (1.79%) thought that regular students could learn better with GLOBE and one teacher (1.79%) thought that accelerated students could learn better with GLOBE investigations, as shown in figure 4.11.

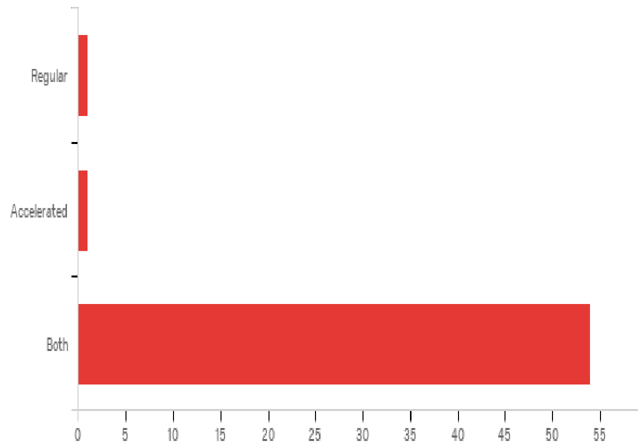

Figure 4.11 Frequency of teachers who thought that accelerated, regular or both types of students learn better with GLOBE investigations.

10. Do you plan to continue to use GLOBE activities and protocols in your teaching practices?

Fifty-five teachers responded to this item, out of which 48 teachers (87.27%) planned to continue to use GLOBE in their teaching practice and only 7 teachers (12.73%) planned to discontinue using GLOBE in their teaching practice, as shown in figure 4.12.

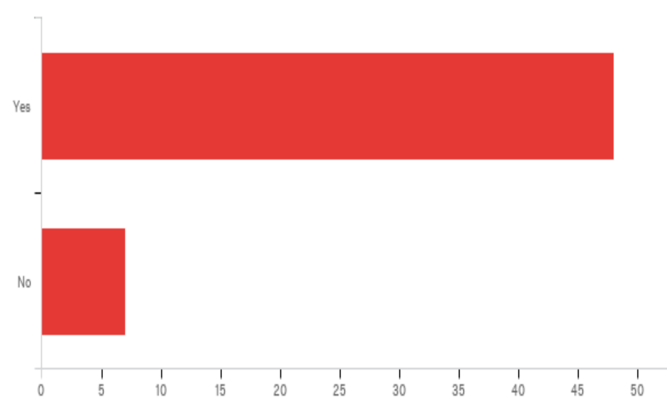

Figure 4.12 Frequency of teachers who plan to continue to use GLOBE activities and protocols in their teaching practices.

11. Choose the GLOBE investigations you were trained in:

Sixty-five teachers responded to this item, out of which 48 teachers (73.85%) were trained in Atmosphere, 33 teachers (50.77%) were trained in Earth as a System, 34 teachers (52.31%) were trained in Hydrology, 41 (63.08%) teachers were trained in Land Cover/Biology, and 36 teachers (55.38%) were trained in Soil, as shown in figure 4.13.

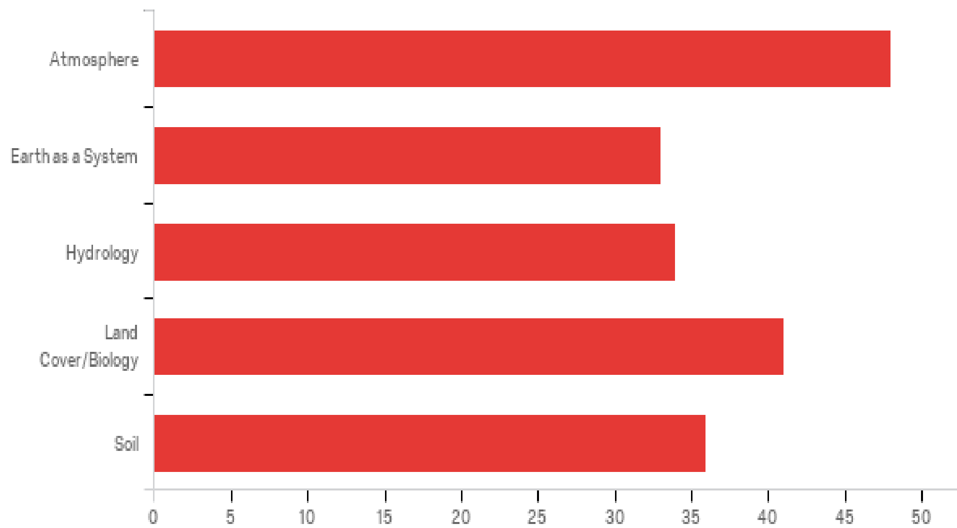

Figure 4.13 Frequency of teachers who were trained in particular type of GLOBE investigations.

4.7 Results of Qualitative Analysis

Each research question was addressed using specific items in the TGTQ. Because responses were anonymous, pseudonyms were used. The first question and related teacher responses follows:

- How do GLOBE teachers integrate GLOBE protocols and investigations into their classroom practices?

It was found that teachers incorporated GLOBE investigations in lesson plans, demonstrated protocols in classrooms, organized field trips for data collection, arranged group projects and discussions in class, and conducted science fair and workshops. Ms. Dolly said, “I integrate hydrology, atmosphere, and soil protocols into those topics. I have the same kids all year for 5th grade general science. Our GLOBE investigations are ongoing with projects shared at conferences or virtual conferences at the end of the year.” Ms. Jessica mentioned, “We set up study sites around school and take field trips to use our GLOBE protocols in different areas”. Ms. Tina said that they use GLOBE data collected by students or downloaded from GLOBE website for project-based curriculum teaching.

In item 7, 51 teachers listed the names of the topics in which they liked to integrate GLOBE activities. Seventy-four percent of teachers mentioned that they like to use GLOBE activites and protocols to teach various topics of environmental education. These included climate change, ecology and human impacts, how factories affect atmosphere, erosion, water quality,atmosphere, carbon cycle, gardening and soil health, weather and climate, clouds, landcover, watersheds, groundwater, pH, ozone, air and water temperature, water health of Gulf, earth layers and interactions within ecosystem, food web, absorption of metals in plants, analysis of heavy metals, pollination and phenology, and biosphere. Ms. Sophia responded, “I integrate hydrology, atmosphere, and soil protocols into those topics. I have the same kids all year for 5th grade general science. Our GLOBE investigations are ongoing with projects shared at conferences or virtual conferences at the end of the year.” Twenty-three percent of teachers teach topics from earth science. They liked to teach topics like planetry science for day length, astronomy and satellites, rotation and revolution of earth, and rocks. One percent used the GLOBE investigations for teaching descriptive writing and math skills. Ms. Roshan said, “I taught my students how to read a rain gauge and how to determine what clouds are in the sky.”

In item 9, 49 teachers listed the names and description of GLOBE activities they enjoyed teaching the most. Twenty-two teachers (44.89%) liked teaching the atmosphere protocols, 17 teachers (34.69%) liked the hydrology protocols the most, 4 teachers (8.16%) liked the land cover protocols, 3 teachers (3.16%) liked doing soil protocols, and 3 teachers (3.16%) liked to incorporate all GLOBE protocols in their teaching. Mr. John explained, “Cloud observations, as it gives everyone the opportunity to get outside, as well as being a good introductory activity with something students have experience with.” Ms. Gunter said, “Elementary Globe has very good activities for the students to complete hydrology, soils and land cover with the teachers and college age students.” Ms. Jane explained, “I enjoy teaching the GPS protocol, and hydrology, and atmosphere protocols the most. The students love posting their data on the wall so see the seasonal changes and then compare them to other places in the world. Participating in a field campaign is great because the students find a connection with a scientist and other schools in the world. The students enjoy working on protocols at our local creek. Their ongoing work has gotten the attention of the city. The students also participate in a creek cleanup each spring.”

The results showed that 17 participating teachers liked to teach with indoor GLOBE activities. The most common factor was location of the school. Some schools were in areas where it was not convenient or safe to conduct outdoor GLOBE activities.

Ms. Sheila mentioned, “I teach teachers and students in under-privileged areas which means not all have the opportunity of going outside because of safety or other reasons.” Mr. Paul said, “I can't always take an entire class outside and we are very urban which makes water science difficult.” One teacher said, “…can't go outdoors due to location.”

It was seen for some teachers that extreme weather conditions made it impossible for them to conduct outdoor GLOBE activities. A teacher thought it was easier to teach a lesson indoors without worrying about the weather outside. Ms. Melisa said, “It's not always feasible to be outdoors. So far I would say it has rained or snowed about half of our days at school.” Mr. Chris said, “I can't always get outside. Especially with the cold and snow.” One teacher also mentioned time and logistic makes difficult to conduct outdoor GLOBE activities.

Two teachers believed it was more practical and easier to teach a lesson inside the classroom. One of these teachers said that she liked using computer visuals for teaching in class. The other teacher said, “Portable and mobile data recording devices to collect data are becoming easier to obtain at least in the schools I have taught in. When data is presented and compiled almost instantly, the effort becomes rewarded with success.”

In the second part of item 18, 40 teachers discussed about their plans to continue using GLOBE activities and protocols in their teaching practices. Of these, 13 teachers were not sure about their plans to continue using GLOBE due to transitions such as changes of courses they would teach, change of jobs and job responsibilities, lack of practice, no funding, and retirement.

Ms. Kristine said, “Just because I am no longer a traditional teacher, however, I will try and convince colleagues of its usefulness.” Ms. Angela said, “I have not been very active lately due to my transitioning in teaching. Though last year I did co-sponsor a training in South Dakota before I moved back to Hawaii. I'm hoping to transfer to a high school where I will have 80 minute blocks of time for instruction. I would like to become active in GLOBE again." Mr. Eric explained, "I just need to become more familiar with it."

The teachers who planned to continue using GLOBE activities and protocols liked to incorporate these activities in their curriculum, science lessons, science fair projects, and resources for elementary, middle and high schools, as well as for undergraduate students. Ms. Jennifer said, "I will continue to use the hydrosphere and surface temperature protocols as I always have. I will be adding more soil protocol related projects this year." Another said, "I plan to use them with my science club and in the classroom. I hope to implement more activities next year." A college teacher, Ms. Celia said, "Mostly GLOBE at Night for undergraduate astronomy and the entire GLOBE program for middle school students."

Some educators planned to share the GLOBE activities for science conferences and teacher workshops. Mr. George stated, "I now work at NASA Goddard doing GLOBE and would share activities with many teachers, professors and trainers." Ms. Jenna stated that she shared GLOBE activities for Ohio View Satellites at the school board meeting and with the city council and stated, "I plan to allow my students to explore the natural habitat of Red Mountain Park by collecting samples of limestone and testing it, testing the soil in various locations of the park, among other things."

The second question and related teacher responses follows:

- Why do teachers integrate GLOBE activities in their teaching?

In item 6, 55 teachers clearly explained the reasons for integrating GLOBE activities in their teaching. These teachers thought that GLOBE activities enhanced classroom instruction and provided deeper understanding of scientific concepts. These activities engaged students in conducting scientific investigations and data collection providing authentic research experience to them. GLOBE activities motivated science learning, problem-solving and critical thinking skills in students. A teacher commented that GLOBE activities are quality activities and do not need tweaking. It provides science process skills and inquiry-based learning.

Ms. Sarah responded, “Data collection motivates students and students seem to be better problem solvers after using GLOBE. Students develop a better understanding of the world around them. In addition, they can use their own data to learn math skills and communicate with others around the world.” Mr. Karim said, “GLOBE activities and protocols are more hands-on than our textbook curriculum and my district does not follow a science curriculum. We have standards but not an official curriculum, the textbook is over 20 years old.”

Ms. Rachel said, “GLOBE teachers believe in involving students in authentic science and inquiry learning. They like investigative approach with the emphasis on skills. They promote higher order student thinking like observation, analysis, evaluation, synthesis, and conclusion.” Another teacher said that these activities are designed to get students involved in their own learning. “I love taking my kids outside so they can explore. I love seeing their faces as they make new discoveries.”

Ms. Rita explained, “I think it is neat that the students realize that they are part of something bigger, that the work they do with GLOBE helps NASA and other scientists, and has global impact. They have the ability to change the world.” Another teacher said, “GLOBE gives the students real world experience and ability to relate to personally.” A teacher said that GLOBE protocols are just what the students would need to see, Earth as one system depending on water, atmosphere, soil, and plants. A teacher responded, “These types of activities help students gain a higher level of understanding and have more independence during activities and also give more a group discussion when applicable.”

In the second part of item 9, these 49 teachers explained that why they enjoyed teaching with GLOBE protocols. These teachers said that GLOBE protocols were appropriate for teaching all grade levels, were relevant and could easily fit into their curriculum, were cost-efficient, provided hands-on experience to students, enriched and expanded teachers’ knowledge and work, keep students involved and interested in science, improved students’ achievements and learning outcomes, prepared students to work in groups, and helped students to get engaged with community.

One teacher who was involved with Project Learning Tree, said GLOBE protocols had helped to enrich and expand her work. Another teacher quoted, “It is very basic and all my students can be successful with this investigation. We are also able to go outside and test the water in a nearby creek.” Ms. Lily said, “They must compare with other groups and check a chart to make sure they are accurate. Throughout the year, I will randomly have students identify different types of clouds. This gives them a better understanding of the world around them. Hopefully, this will get them interested in meteorology or other types of science careers. We also look at storm clouds and discuss weather." Another teacher, Ms. Dean wrote, "Students learn to read instruments and relate information they collect." Mr. Delores mentioned, "The atmosphere protocols are in every school's curriculum and they are great hands-on activities for students of all ages."

A teacher from a rural community, Ms. Barnes explained that soil protocols helped the students to understand the importance of impacts of chemicals in agriculture and its influence on environment and organisms. A teacher from Hawaii thought that land cover and hydrology protocols gave the students the opportunity to get involved with citizen science and become familiar with their environment. Ms. Garner said, "GLOBE doesn't require specific, expensive equipment." Another teacher explained, "It is most relevant where I teach, especially with the severe lead issues many of our communities and schools have been having." According to Ms. Virginia, "These activities get my students outside, they make determinations based on their observations and learn to trust themselves."

In the second part of item 11, 52 teachers explained why they would like to integerate indoor or outdoor GLOBE activities. As shown in figure 10, most of the teachers liked to use outdoor GLOBE activities during their classroom practices. These teachers explained that students enjoy learning outside. A teacher quoted, "My students learn more from outdoor activities. They are stuck in a classroom for hours at a time."

Another teacher said, “Learning in the outdoor laboratory is superior.” Ms. Hannah quoted, “Kids like being outside and it is more realistic to be out doing the protocols.”

Ms. Donald said, “I would like to implement more outdoor activities to give them the opportunity to explore the environment.” Ms. Peggy thought, “Students need outdoor activities to give them the opportunity to explore the environment.” Some teachers thought that it is important to implement GLOBE activities outside as it is related to earth and environment. Ms. Elizabeth quoted, “Earth science happens outside.” One teacher gave the example of teaching weather patterns using GLOBE activities and said that when students measure the temperature and other weather-related factors, they understand it better. A similar example was given by another teacher relating to types of clouds.

Some teachers thought that due to computer technology students have developed the unhealthy habit of staying indoors most of the time. Therefore, it was important to take them outside. Ms. Nancy said, “Students today do not learn that outside is a wonderful place to be. They are so glued in to computer activities and interactive white boards that they forget that learning can be taken outside too.” Ms. Brenda said, “Students spend too much time indoors and have lost touch with the outdoor environment. This is shown by student apparel since they wear shorts and tee shirts to school in the middle of winter.”

The third question and related teacher responses follows:

- How do teachers implement GLOBE activities to enrich STEM education in class?

In item 16, 34 teachers explained the implementation of GLOBE activities to enrich STEM education in class. The participating teachers said that they incorporated GLOBE activities within weekly lessons in class. The results showed that GLOBE teachers engaged students and developed inquiry research projects and case studies that utilized GLOBE data. They conducted actual field work and investigations with students using GLOBE protocols following discussions with people in government agencies and scientists. A teacher quoted, “We also bring in wildlife biologists and city officials.” Ms. Robert mentioned, “GLOBE activities have been featured in our school science fair for the last two years. Students have developed their own projects related to activities they have been involved within class.” Ms. Jasmine shared her experience and said, “I use them in conjunction with Project Learning Tree activities which are STEM-based. This is when I do field days/events for schools.”

Teachers used GLOBE activities as a part of the core curriculum, to enhance their lessons, and to give the students hands-on experience in science. A teacher mentioned, “STEM education is nothing new. It is integrating, and thinking more holistically about science. GLOBE is a great vehicle for enabling students to think that way. GLOBE bridges all disciplines, math, science, engineering, and technology.” M. Debbie said, “Sometimes we read about current issues in water and then we conduct tests to determine how they found their results. Sometimes students have ideas and if I can fit them into the curricula somewhere, they get to use GLOBE to gather data. Collaborating with other schools outside of our city is also something we have done.”

In item 17, 32 teachers explained ways to convince others teaching any science or STEM course to use GLOBE activities in their teaching. According to them, it can be done by sharing GLOBE training materials, sharing some sample activities with other science teachers, and by talking to them about their teaching experiences using these activities, and telling them how these were useful for science teaching. One teacher shared her experience and said, “All I have to do is describe it and they want to learn more, the protocols are easy to follow and all student and teacher materials are provided.” Mr. Jim said, “Showcase an activity or protocol. Once they see it, they want to do it.”

The teachers gave ideas and examples of how to share GLOBE activities such as performing a demonstration of a protocol at a professional development session or faculty meeting. Mr. Patrick quoted, “A science teacher’s association conference would be an ideal place to lead a workshop session on one protocol. Just try one protocol and implement it into your curriculum. Teacher will see how easy it is and the increased benefits in student learning and understanding. Once you start using GLOBE you'll get hooked. But, start slow - one or two protocols. Custom design the GLOBE protocols and activities to meet teacher / student goals and all will work fine.”

The results showed that it was important to model a lesson using GLOBE activities and present a data collection. This explained the importance of GLOBE activities to real-world data relevance and its applicability to convince other science teachers. A teacher said, “I give them a demo and explain the over-arching goals of the program. It usually meets many of their science objectives.” Ms. Carla said, “You must convince the teachers that it is unique and you must build their confidence and assure these activities are state and national standards aligned. As a trainer for GLOBE, an important element in the equation of accepted classroom practices is winning over the principle. You must win them over.” Mrs. Stacy commented, “Many teachers see it as additional work, since it is not just teaching from a book which can be easier but students gain little from textbook knowledge. We do not need another generation of remembers, we need thinkers and doers. Yes, it is more work but my students were scientists and the state tests scores were almost 80% passing so the proof is in the data."

The fourth question and related teacher responses follows:

- What types of challenges do teachers report implementing GLOBE investigations into classroom practices?

In item 13a, 55 teachers described the challenges they faced when implementing GLOBE investigations into classroom practices. More than 50% of the participants reported time constraints. Other challenges mentioned were lack of equipment, limited resources, fitting with the curriculum, lack of administrative support and GLOBE training. A teacher stated that time was too short to teach and do the activities of GLOBE and the public curriculum. Another teacher said, "The pressure on the teachers and students to maintain a quantity of content knowledge measured by state assessments inhibits the time needed for proper investigations. The process of obtaining quality data and revising or modifying methodology is short changed due to time constraints. The push for rigor and depth in obtaining content knowledge requires time."

Mrs. Henry said, "Finding time to take them outside and bringing them to the river to conduct water quality testing-arranging all of the trips throughout the year but it was well worth it." Ms. Hope said, "Time to do, time to enter data, and then to review the data. Now days, just getting students out of the classroom and outside. Much more difficult to do at the elementary level." Ms. Robbins mentioned, "Due to very poor internet at our school, it is not easy to use programs like GLOBE." Another teacher complained that the lack of materials was a real problem, for which there was no time, and sometimes it was not directly relevant to curriculum. Ms. Tracy said, “The struggles that I face are time limitations and support from fellow faculty members.” A participant said that most of his students enjoyed going out and measuring. They collected data even on weekends and during their school holidays. Mr. Bryan said, “I do not really have struggles with implementing GLOBE in my classroom. I started small with surface temperature, cloud cover the first year. Participating in a field campaign is important for motivating both teacher and students during the first few years.”

In item 13b, 39 teachers specifically described struggles with collecting data. Time constraint was the most common problem. Other issues included limited equipment, resources, student training, and entering data on website. A teacher quoted, “Limits on the time it takes to travel to collection sites, set up equipment, and conduct the procedures. Optimal teaching opportunities present themselves many times during field laboratories, especially with the younger students. The struggles with older students usually comes through equipment malfunction or its proper maintenance.” A teacher said, “We are very short on time and must prepare students for state testing. This takes priority to anything else we would like to implement into our classrooms. Fifth graders are good at collecting data.” Ms. Amanda said, “Finding funds for replacement instruments is hard sometimes. More grants would be helpful.” A teacher said that her class could not collect data directly because their atmosphere instrument shelter and rain gauge were vandalized. Then she started collecting data for the students in her backyard and involved the class to enter it on the GLOBE website but her students did not enjoy doing so. It was also challenging to train the students to use the instruments correctly for data collection.

In item 13c, 31 teachers specifically described struggles with uploading data to GLOBE website. Six reported that they did not have any issues in entering data on the website. According to remaining participants, time constraint was the biggest issue to upload data. Other problems were availability of computers, internet and connectivity issues, website issues, and not having enough technology skills to train students to upload data on the website.

Mr. Bolton said, “Historically, it has been very difficult. Not all technology is created equal so time becomes a limiting factor when troubleshooting skills are lacking. When students and teachers are unsuccessful at this stage, it doesn’t take much to assign this a low priority due to the lack of time.” Another teacher stated that connection problems would postpone entering the data and the availability of computers would cause delays. Ms. Walters said, “Time and how to do it with 60 students all collecting data.” Ms. Rose complained, “We have problems with the new website, sometimes we do not understand why we can't upload.” A teacher explained that in order to enter data before end of class they needed to rush, otherwise it was not possible to complete data entry.

In item 13d, 31 teachers specifically described struggles with analyzing and explaining data. Eight reported that they did not have any problem in analyzing data. The respondents listed the following as major issues in analyzing data: lack of time, lack of connectivity and website issues, and the students’ lack of ability to analyze and interpretation graphs.

Ms. Mariam quoted, “The website does not always work. Sometimes very slow and can't find our data. Can't analyze what you can't find. Takes time which we don't always have. Tend to need more time to review and analyze data than to collect.” Another teacher said, “There were few struggles with this beyond converting downloaded CSV files to Excel files that can be analyzed.” Ms. Julie said, “This is the area of most difficulty. Participants/ including myself have difficulty finding their data after submitted to retrieve it for review. I need to look into data with tutorial and incorporate that as a large part of the trainings.” According to Ms. Janice “With younger students, this becomes more difficult and requires more time. With older students, the same can be said only the level of difficulty and expectations are higher. The limiting factor at this point is confidence and familiarity through practice is lacking.”

In item 13e, teachers specifically listed the following struggles in implementing GLOBE: unfamiliarity with other teachers, finding other schools for conducting group projects, incorporating GLOBE program at university level, and lack of administrative support. Ms. Hayleigh explained, “I have been frequently changing my teaching location and assignment; it has been a struggle to remain active in GLOBE.” Another response was that the students would love to do projects with others, but it was difficult to find other schools to actually connect the students. Ms. Susan stated, “The struggle is the administration's trust, the unfamiliarity of GLOBE by teachers as well as performing outside the teacher's comfort zone and protection of the classroom.”

The fifth question and related teacher responses follows:

- What kind of successes do teachers experience during implementing GLOBE activities?

In item 14a, 36 teachers discussed their successes during implementing GLOBE activities. Four teachers reported that they had not had much success with GLOBE implementation. The remaining participating teachers successfully engaged students with data collection and scientific investigations as they enjoyed using hand-on activities in class. The teachers were able to improve the confidence of students. The experience with GLOBE activities gave students a sense of accomplishment and responsibility. It provided a better understanding of problem-solving and reasoning skills. The involvement with GLOBE activities helped students to understand the importance of data collection and scientific investigations, improved their ability to download, analyze, compare, interpretate, share and predict data. The teachers using GLOBE activities were successful to improve students' capability to discuss, collaborate and present their data to the community.

Ms. Brannon quoted, "I have had a great deal of success with implementing GLOBE activities into my classroom. My administrators over the years have seen the awesome projects that the students have done, celebrated with the students when they have won GLOBE prizes for earth day videos, virtual research conferences, and allowed students to travel to two separate annual meetings to share their work with GLOBE. Students have learned to think about science deeper using GLOBE. The kids utilize technology as they connect with other schools, making videos, taking photographs, using satellite images, producing their project posters." Ms. Reams shared her experience and said, "I had no problems implementing GLOBE into 9th grade Earth and Space Science. For the weather unit, I pretty much used GLOBE atmosphere protocols and activities that matched the curriculum. Did the same with hydrology protocols for teaching the water cycle. GPM and SMAP were not around when I was in the classroom. I designed the Environmental Science class around GLOBE and students performed just about all protocols in each GLOBE area."

A teacher stated that involvement with GLOBE activities allowed students to see how science works. Another teacher said that students like doing hands-on activities. Ms. Young quoted, "The students seem to enjoy the activities, especially those outside." Mr. Larry stated, "Students really enjoyed the GLOBE Program as it added interesting diversion to a sometimes "boring" topic. Hands on activities always seem to go faster." Ms. Chan quoted, "The children enjoy the activities that are set up with the GLOBE protocols as well as being aligned with the standards." Another teacher Ms. Nicole said, "It has helped grasping vocabulary and scientific method."

A teacher said that students seem to be learning. Mr. Sam quoted, "In years past, I have students do better on assessments and be able to problem solve better. GLOBE has provided my students with opportunities to hear different points of view and work collaboratively." Ms. Shawn said, "The students always want to connect more. They are fascinated. I currently have students working to collect data and share with other schools." Ms. Deena stated, "In years past, I have students do better on assessments and be able to problem solve better. GLOBE has provided my students with opportunities to hear different points of view and work collaboratively."

The participants said that they were able to implement GLOBE activities in various lessons and science fair projects. A teacher said that students were easily able to upload and download activities and were excited to work with real data and satellites. Ms. Jocelyn said, "Students liked the GLOBE at Night and where able to identify constellations and enter data. The lesson worked well with our regular astronomy course." Another teacher thought that students gained a better understanding of problem-solving, reasoning and team-building skills. Ms. Lindsey said, "Students take on responsibility for home water health and making adults aware of the importance."

In item 14b, 33 teachers responded and discussed their successes with collecting data during GLOBE activities. Three teachers reported no success with data collection. The remaining participating teachers were successful in involving students with data collection using GLOBE protocols. A teacher said that her students were eager and willing to participate in data collection. Ms. Katelyn stated that students could easily get trained in data collection. She said, "Once a student is trained, they are experts." Another teacher said that by using GLOBE activities in class, students were exposed more to data collection and this practice made them a competent learner. Ms. Kathy said, "Since February we are able to collect, analyze, and put the data on the website of the Globe. Without missing a single day of school." Mr. Terry said, "Middle school students liked the atmospheric observations and learning about the clouds. They also enjoyed the ocean hydrology protocols.

Students recognized authenticity of collecting data as it relates to science. Ms. Darwin shared her experience that engaging her students with data collection using GLOBE protocols detected the presence of lead in the supply of their school water. She said, "The administration would not believe me that the school water was bad until students took their results and actual test samples down and explained it to the principal. Then the professionals stated that they had lied about testing our water. It was contaminated with lead and my students proved it." Ms. Kerry stated, "We were able to have the freedom to collect data and work outside as needed. The administration basically left us alone."

A teacher said that with data collection students learned a sense responsibility and accomplishment. Ms. Joyce quoted, "It has been fun because we launch a high-altitude balloon each spring for our atmosphere unit and collect data. It means a lot to them that they have ownership of the data." Ms. Hayden added, "Fifth graders love to collect data. The cloud identification and cloud cover seems to be the most challenging. Students are very responsible about collecting water samples and running water quality tests, macroinvertebrate sampling, surface temperature and snow cover measurements."

The participants said that they used multiple sites for data collection of hydrology and land-cover. Ms. Ingram quoted, "Green-up and Green-down data takes ten minutes at the end of class. Club members collect and analyze water samples monthly for GLOBE and a Division of Wildlife project in our state." Ms. Alison said, "After training some students how to collect data for each protocol. These students were then responsible for teaching other students how to do. I just did quality control when needed. I'll use my Environmental Science class as an example. While learning a specific protocol we would go outside as a group, collect data and discuss what we needed to do. After that, time was given each Friday to collect data, return and enter into the GLOBE database. I had two students responsible for getting data from other students and entering it. Every few weeks that job was rotated around so every student learned how to enter data. I made it part of the final test. We would go out to a State Park and do all the GLOBE protocols."

In item 14c, 30 teachers responded and discussed their successes with uploading data to the GLOBE website. Four reported no successes with uploading data to the website.

Three teachers said they need to practice and were not sure about uploading data to the GLOBE website. Two teachers said they did not try to upload data. One of these teachers explained, "Since I am not in a formal school, I do not have a site which I can keep current data to upload. I simply show teachers how to collect data and explain how they can become GLOBE trained and set up a school."

The remaining participating teachers were successful in uploading data to the GLOBE website. A teacher said that students used the iPad and liked using the GLOBE app. An elementary school teacher, Ms. Rosie said, "Fifth graders are easy to train in uploading data. We save all of our data sheets for a few weeks and then get a computer cart to have a data entering blitz that takes about fifteen minutes to enter it all." Another teacher said that the students loved to upload data and it was easier for them to do so. Ms. Maggie said, "I would say this can be a struggle at times, but always works out." Majority of respondents thought that it was easy to upload data on the website, especially for the students. Ms. Mitchell quoted, "Students did not have too difficult of a time uploading data. For a day or so we would do as a class. I would project up on the screen so all could see and then everyone sooner or later had to enter data. We were also working with some of the GLOBE scientists, so students also learned how to email mass quantities of data to the soil scientist."

In item 14d, 28 teachers responded and discussed their successes in analyzing and explaining data. Five reported no success. A teacher said in her response that as a part of their curriculum, her students drew and analyzed graphs and then wrote a report for conclusion. Another teacher said that her class looked at the oxygen level for water quality analysis. A participating teacher said that she had used an inquiry guide to show the students how to perform analysis. Ms. Jenna quoted, “Hard copy analyzing data soon after collection works best I have observed, or looking at sample data already prepared.” Another teacher, Ms. Summers shared her experience and said, “Analysis is more difficult for fifth graders. I get help form local resource people to help the kids with water quality understanding. Our local soil and water conservation office is great at helping with the macroinvertebrates. The easiest way to help kids learn to analyze and explain their data is to have them compare their data to another school in a different latitude or climate region. We have skyped with schools to talk about their data together. That helps the young students understand it better.”

A teacher responded that once the scientific concepts were explained clearly to students, they were able to analyze data and see the patterns. Ms. Armani quoted, “Students have developed a talent for analyzing data over the time we have been collecting data.” Another teacher said that data analysis was an ongoing process which became easier with time. Ms. Anita shared an activity and said, “I taught in a block schedule so starting with the spring semester students would start collecting daily high, low temperatures and precipitation. Students in the fall semester would continue. Right after the Christmas holiday, students would take this data from the entire year and analyze. Students had to determine if that particular year was warmer/cooler/wetter/dryer than the previous year. We also had data from the National Climatic Data Center for our area for the past 112 years. So, the students then had to see what the 5 years, 10 years, 25 years, 75 years, and 100 years averages looked like. They would then have to make a conclusion if the climate in our area was changing.”

In item 14e, 22 respondents discussed their other successes with GLOBE. Four reported no successes. They shared their ideas about how they were using and sharing their GLOBE data with NASA, local newspapers, local people, and other schools. Ms. Catherine shared her success story that she had conducted a research project on El Nino during the winter of 1997-98 to make predictions for their area and presented it at an international conference in Finland. Her school project was chosen for one of the best projects among the other participating schools from other two countries, Netherlands and Finland. This teacher also won the Presidential Awardees for Excellence in Teaching Math and Science from Mississippi in 1999 and visited Washington due to involvement with GLOBE projects.

Ms. Jade quoted, “One of my student groups saw that all of the trees were cut down along the creek at one of our city parks last summer. They used previous years of data from our school and compared it to after the trees were cut down. They are presenting their finding to our city council about the negative changes.” A teacher said that students get motivated and develop a positive attitude with data collection and analysis using GLOBE protocols. These students wanted to continue collecting data even after they had moved on to a different grade-level. Ms. Sonya claimed that her students regularly participated and won in the State Science Contest using GLOBE protocols for their projects. Similarly, a teacher from a rural community school every year used GLOBE hydrology and soil protocols in four different farms in the area as a practice with her classes. They found odd changes in their soil and hydrology results on comparison with the previous year’s results and reported to the relevant authorities for further testing. A gas leakage from a gas station was detected that was mixing with the spring water running to the school. The authorities then closed down the gas station.

Ms. Nancy quoted, “The interconnection of the spheres of the Earth made it possible to integrate the topics used in the curriculum with the protocols of the hydrosphere, atmosphere and Biosphere managed to integrate the school in one big project involving all school segments.” Another teacher Ms. Boyle said, “We conduct a watershed study of a major stream in our county and city and have done so for four years. This provides a benchmark and basis for determining changes in the water quality of the stream.” Similarly, Ms. Fatima shared her success and said, “All students could be successful with this model because collecting data can be done by anyone and students with special needs can interact with their peers more successfully. It also gave them a base of understanding that helped them on their standardized tests later.”

The sixth question and related teacher responses follows:

- In what way has GLOBE training influenced teachers’ scientific knowledge?

In item 3, 53 teachers explained the way GLOBE training influenced their scientific knowledge. These teachers believed that GLOBE training improved their scientific content knowledge, provided them with better understanding of scientific concepts and resources, enhanced their science teaching skills in an organized way and improved pedagogy. Ms. Tanya quoted, “GLOBE gives the opportunity to conduct scientific investigations by developing the accuracy of observation and clarifying good data archiving. GLOBE develops a sense of confidence toward any argumentative inquiry and investigation.” Ms. Doris explained, “I like working with real data and so do the students. It has real meaning for them.”

Ms. Thornton believed that GLOBE training has influenced her classroom practices and provided hands-on resources. She said, “It gave me a broader perspective and resources on how to better effectively teach science. The hands-on curriculum is priceless.” Ms. Jamie said, “GLOBE training showed how to do hands on.” Another teacher, Ms. Thames, said that during GLOBE training she gained knowledge about weather and atmosphere and learned to conduct useful experiments with her students. Similarly, one more teacher, Ms. Shahnaz, talked about her experience with weather devices during the training and said, “I was not aware of all the devices that were used in studying weather and the atmosphere.” GLOBE training enhanced teachers’ content knowledge and taught them data collection techniques. Ms. Salina quoted,” I learned about the clouds and collecting data.” Mr. Scott said, “The GLOBE training was very informative. It broke down different science subjects and puts them in order. I was very informed after the training. I even learned a few new things from the training.”

GLOBE training enhanced confidence in teaching science. Ms. Khan said, “GLOBE training has helped me to be able to feel more confident in helping students obtain scientific knowledge about our local environment. The procedures have been helpful.” Ms. Nancy said that GLOBE training has helped her gain a better understanding of watersheds, groundwater, environmental science and human impact. Mr. Rogers said, “GLOBE expanded my knowledge about the natural world with the hands-on experience. It took me out of that cookie cutter mode of teaching in a classroom lab setting.” Another teacher, Ms. Clinton said, “I acquired a much strong science content background through using GLOBE. The hands-on, actual doing of science concepts is much better than reading about it or through lecture. Plus, working with and helping students work through the protocols really strengthens your knowledge and abilities. Working with GLOBE scientists helps too."

GLOBE training helped teachers understand how to conduct scientific research by engaging students. Ms. Deborah said, "I gained a better understanding of how to engage students in independent scientific research." Ms. Carlita said, "I was able to gain more content knowledge using the hands-on protocols." GLOBE training could help any teacher with a different major to teach science. As Ms. Darlene quoted, "I received GLOBE training during my first three years teaching. It really helped me better understand concepts. At that time, I was an elementary ed. major and never intended to teach science. Now I love it." Ms. John said that GLOBE training helped to improve her science knowledge and especially knowledge in environmental science. Ms. Charlotte said, "It did not impact my scientific knowledge, but it did positively impact my teaching."

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The ninth question and related teacher responses follows:

- Why have GLOBE teachers stopped using GLOBE in their classroom practices?

In item 2, 67 teachers responded and explained that either they have stopped or continued using GLOBE in their classroom practices. The results showed that 48 teachers (71.64%) had continued using GLOBE and only 19 teachers (28.36%) had stopped using GLOBE in their courses. Of these, eight teachers (42.11%) had total BARSTL scores between 76 and 89. One teacher had a total BARSTL score of 76, one 80, one 85, one 86, one 87, two 88, and one 89. Of the remaining teachers who had stopped using GLOBE, eleven had total BARSTL scores between 93 and 101. Two teachers had scores of 93, four 95, two 97, two 100, and one 101. All the responses were analyzed and it was found that 12 teachers had stopped using GLOBE due to a change of teaching assignment or curriculum. Three stopped because they needed more GLOBE training. Two stopped due to time constraints and two had stopped due to cost.

Representative comments follow. A teacher said that she had to stop using GLOBE because she switched from science to teach another subject. Another teacher said that due to teaching all subjects, she was required to focus on Math and Language Arts and had to discontinue using GLOBE in her classes. Ms. Diane responded, “Can't fit it in the curriculum, I would have to give up some required material to do GLOBE.” A teacher complained that she had to give up GLOBE because of no administrative support. Ms. Steven quoted, “I no longer teach regular classes.” Ms. Gordon said, “I feel I need more training and exposure using the GLOBE program. Also, I am just so overwhelmed trying to get the state curriculum addressed.” Another teacher mentioned that she no longer had funding to attend GLOBE workshops, so she did not have the confidence to continue teaching with GLOBE activities.

4.8 Summary

The purpose of this study was to understand teachers’ beliefs about incorporating GLOBE investigations in their classrooms. The quantitative analysis was done to measure the teaching beliefs of GLOBE teachers using a one-way ANOVA in SPSS. Necessary follow-up analysis, including post hoc tests, were done where significance was found. The pedagogical beliefs of GLOBE teachers were measured using the Beliefs about Reformed Science Teaching and Learning (BARSTL) questionnaire. Using the

TGTQ and BARSTL together provided a complete picture of the teaching beliefs and practices of GLOBE teachers.

The BARSTL scores from this study revealed that the vast majority (93.06%) of the GLOBE teachers are inclined towards constructivist teaching beliefs. The one-way ANOVA results showed no significance for age and years of teaching experience. It was only significant for the region where GLOBE teachers teach. The regions showed the significant differences maybe because of small sample size and because of uneven distribution of the sample in each region. It was seen that 44.44% participating teachers were from SE, 18.06% from NE, 6.94% from MW, 13.89% from SW and 16.67% from NW regions. Therefore, NE, MW, SW and NW were combined together as one group and were compared with SE region for statistical analysis.

Results from the TGTQ highlighted the struggles and challenges teachers faced during classroom practices. Sixty-one percent of the teachers had changed their teaching strategies after learning GLOBE protocols and incorporated more hands-on inquiry-based activities in their teaching. Examples included incorporating GLOBE investigations into lesson plans, demonstrating protocols in classrooms, organizing field trips for data collection, arranging group projects, holding discussions in class, and conducting science fairs. Eighty-two percent of the teachers planned to continue teaching with GLOBE activities and protocols. Ninety percent of the teachers believed that teaching with GLOBE had influenced their students' learning. Ninety-six percent of the teachers indicated that both accelerated and regular students learn better with GLOBE investigations. One teacher said, "I believe that hands-on experience helps students develop a deeper understanding of scientific concepts". Seventy-one percent of the teachers would like to implement more outdoor GLOBE.

The results from this study revealed that GLOBE teachers believe that GLOBE training had influenced their teaching skills and improved their scientific concepts. Figure 4.12 with responses from item 18 of TGTQ showed that only seven teachers (12.73%) did not plan to continue teaching with GLOBE activities while forty-eight teachers (87.27%) wanted to continue teaching with GLOBE activities and protocols. The total BARSTL scores of these seven teachers ranged from 77 to 97: one teacher with a score of 77; two with a score of 88, one with a score of 91, one with a score of 95; and two with a score of 97 score. A teacher said that she wanted to continue teaching with GLOBE by incorporating activities and protocols in science lessons. Ms. Aleena quoted, "To continue the water quality training and add some other components this next year. I will be teaching at a new school this next year and also want to make data entry more of a priority. We hope to have our students participate in the weekly/ monthly challenges." It was interesting to find out that the teacher with the lowest BARSTL score of 76 had discontinued using GLOBE in classroom practice but wanted to teach with outdoor GLOBE activities and planned to continue teaching with GLOBE activities.

Thus, we may conclude that GLOBE training positively influences teachers' teaching beliefs and practices. It provides teachers with the confidence to teach science and helps to improve classroom practices.

CHAPTER V – DISCUSSION

5.1 Summary of Study.

The purpose of this study was to investigate the teaching beliefs of GLOBE (Global Learning and Observations to Benefit the Environment) teachers, and to analyze their pedagogical practices related to GLOBE. The objective of this research was to identify the connection between teaching beliefs and practices using a descriptive research study approach. This study contributes to the knowledge gap identified by Crawford (2007) between teachers' beliefs of teaching science with inquiry and practicing science with inquiry in the classroom using GLOBE as the context. The barriers in implementing GLOBE (Means et al,;2001) and factors associated with different levels of implementation (Penuel & Means, 2004) were also analyzed.

This study was built on the foundation laid by Sampson et al. (2013) in their development of the 'Belief about the Reformed Science Teaching and Learning' (BARSTL) questionnaire (Sampson, Grooms, & Enderle, 2013). The pedagogical beliefs of GLOBE teachers using the BARSTL instrument were measured. The overall BARSTL scores and the BARSTL scores of the four components were calculated using the method established by Sampson et al. (2013). Descriptive statistics, frequency analysis, and graphing tools were used to examine the overall BARSTL score and the BARSTL scores of the four components. The differences between teaching beliefs and various demographic factors including age of teachers, number of years of teaching experience, and regions where GLOBE teachers teach were examined using one-way ANOVA in SPSS. Necessary follow up analysis, including post hoc tests, were done where significance was found.

Qualitatively, the influence of the GLOBE program on teachers' classroom practices, scientific knowledge, and learning were explored using the Teaching after Globe Training Questionnaire (TGTQ). The frequency responses of the respondents in the type of GLOBE training, grade level of students, and state and institute (private or public), and where the GLOBE teachers taught were studied to explore how GLOBE teachers integrate GLOBE activities in classrooms. The most common responses given for the short answer questions were coded and analyzed. The open-ended questions helped to analyze how GLOBE training enabled teachers to integrate inquiry-based science activities in class. They also highlighted the struggles and the successes GLOBE teachers faced in implementing GLOBE investigations in classroom practices.

5.2 Description of Sample.

Data was collected from 72 GLOBE teachers across the U.S. from public and private institution using Qualtrics.com. The link to the questionnaires was emailed to GLOBE partners who then distributed it to the teachers in their regions. Participating teachers were from the five GLOBE regions in the U.S. Thirteen (18%) participants were from Northwest, 10 (14%) from Southwest, 5 (7%) from Midwest, 32 (44%), from Southeast and 12 (17%) from Northeast & Mid-Atlantic.

The participating sample consisted of teachers from different grade levels. 50% teachers in high schools, 9.72% taught in middle schools, 13.89% taught in elementary schools, 9.72% taught K-12 grades, 11.11% taught in colleges, and 5.56% teachers taught both college and K-12 grades. It was reported that 27.91% teachers had 1-10 years of teaching experience, and 35.82% teachers had 11-20 years of teaching experience. In addition, 28.17% ranged from 20-40 years of age, and 30.99% teachers ranged from 41-50 years of age.

5.3 Description of Study Variables

The dependent variables in this study were comprised of the results of the BARSTL (Appendix B) that was administered to the GLOBE teachers. The principal set of variables were the total BARSTL score and the BARSTL scores of the four components, calculated from questions 1-32 using the scoring method developed by Dr. Sampson, et al. (2013) and described in Chapter 4. Overall BARSTL scores range from 32 to 128, where 32 to 79 indicates a continuum of traditional teaching beliefs, and 81-128 indicates a continuum of constructivist teaching beliefs. In addition, the results of the demographic questions (independent variables) from TGTQ (Appendix A) were used in examining differences between the BARSTL scores and teaching practices. Finally, the responses from items 1-18 of TGTQ, which also included short open-ended questions, were coded and provided additional information.

5.4 Discussion and Analysis of Research Questions.

The study provided evidence about how GLOBE teachers implemented GLOBE activities in class. This study also provided information on the effect of GLOBE training on teachers' teaching strategies as well as their scientific knowledge. By looking at the BARSTL scores and using TGTQ, we were able to find out whether the teaching beliefs of GLOBE teachers aligned with their teaching practices or not.

5.5 Quantitative Analysis.

Analysis of the BARSTL scores revealed that the vast majority of the participating GLOBE teachers (93.06%) held constructivist teaching beliefs which, in turn, aligned with inquiry-based teaching. Their overall BARSTL scores fell between 81 and 117. The total mean BARSTL score was 94.31. Only 4 (5.5%) of the GLOBE teachers scored between 76 and 78 - which is still very close to the boundary score of 80 – and 1 (1.4%) scored 80. This result verifies that the participating GLOBE teachers held more constructive teaching beliefs than traditional beliefs. As GLOBE is an inquiry-based program, this result is affirming.

The mean BARSTL scores for four components (How People Learn about Science, Lesson Design and Implementation, Characteristics of Teachers and the Environment, The Nature of Science Curriculum) were analyzed. The mean scores of each component were greater than 20 out of 32, providing additional verification that the participating GLOBE teachers held more constructivist based teaching beliefs than traditional.

The frequency data showed that the highest mean total BARSTL score was 98.40 for teachers with 21-30 years of teaching experience. The highest mean total BARSTL score was 96.86 for teachers between 41-50 years of age. This would indicate that teachers with more teaching experience and older in age hold more constructivist teaching beliefs and this may reflect in their teaching practices.

One-way ANOVAs were used to determine the differences between the demographic data obtained from the TGTQ (number of years of teaching experience, age of teachers, region, and the type of institutions in which they teach) and their total and component BARSTL scores. No significance difference was found for the age of the teachers or for years of teaching experience. Only the region in which they taught had a significant difference on total BARSTL score and the Nature of Science Curriculum component score. However, this was due to the small sample size in four regions: 44.44% were from the Southeast, 18.06% from Northeast, 6.94% from Midwest, 13.89% from Southwest, and 16.67% from the Northwest regions. Therefore, the latter four regions were combined together as one group and compared with the Southeast region for statistical analysis.

5.6 Qualitative Analysis

Qualitative analyses were performed to study the teaching practices of GLOBE teachers using the Teaching with GLOBE after Training Questionnaire (TGTQ). The open-ended questions provided insight into the GLOBE teachers teaching beliefs and practice. GLOBE teachers reported how they liked to integrate GLOBE activities in lesson plans, demonstrate protocols in classrooms.

GLOBE teachers incorporated hands-on inquiry-based activities in their teaching practices. Seventy-four percent of the teachers reported that they liked using GLOBE activites and protocols to teach various topics of environmental education, and noted in particular the Hydrology, Atmosphere, and Soil protocols. GLOBE teachers reported that they had the courage as well as the skills to take students outdoors for data collection and conducting scientific investigations. They reported enjoyment in organizing field trips for data collection, arranging group projects and discussions in class, and conducting science fairs.

The results showed that 71.19% of the GLOBE teachers enjoyed using outdoor (rather than indoor) GLOBE activities during their classroom practices. These teachers explained in their responses that their students enjoyed learning outside. Therefore, they encouraged their students to collect real-time data, analyze data, interpretate results, make comparisons and draw conclusions. A teacher discussed that while investigating with GLOBE protocols, their class noticed the problem of lead pollution in their city water and then involved the city council to resolve the issue. This makes it evident that the teaching practices of GLOBE teachers align with constructivists teaching beliefs. They involved their classes in community projects like the local creek clean-up project and participated in science fair projects and conferences. Only 28.81% of the teachers preferred indoor GLOBE activities citing location, weather, time and cost issues.

The results showed that 60.94% teachers changed their teaching strategies after learning GLOBE activities. They became more organized, started planning better lessons and began adopting more hands-on, student-centered activities in their lessons. They began conducting investigative group activities by using GLOBE protocols. It can be concluded that GLOBE training gave teachers the confidence to implement inquiry in teaching science. It enhanced teacher resources and helped them perform better. After becoming trained GLOBE teachers, they took students outside in the field and performed better in conducting scientific investigations. GLOBE training gave teachers a deeper understanding of scientific concepts. Therefore, by using GLOBE activities, teachers got a better chance to practice their teaching believes and implement hands-on activities inside and outside the class.

It was revealed that 89.66% teachers believed that GLOBE had influenced their students' scientific knowledge. The teachers explained that they thought that students had become motivated learners and started developing more interest in learning science and math skills by using GLOBE activities in their classes. They reported that by doing hands-on GLOBE protocols, students got a deeper understanding of scientific concepts and could retain scientific information well. GLOBE investigations also improved students' critical-thinking and problem-solving skills. By participating in research projects, students became independent learners, started thinking like a scientist and showed interest towards careers in science, math, technology and engineering.

It was revealed that 71.64% of the teachers were continuing to use GLOBE in their courses and 28.36% had stopped using it. These teachers had discontinued teaching with GLOBE due to four reasons. Some teachers had a change of teaching assignment or curriculum or because it was not relevant to their teaching assignment. Some teachers thought they needed more training in GLOBE, and a few stopped due to time limitations while for some teachers cost issue was the reason to discontinue. The total BARSTL score of the teachers who had stopped using GLOBE ranged from 76 to 101. This included teachers with traditional, balanced, and constructive teaching beliefs. We found that one of the teachers who did not hold constructivist teaching beliefs had stopped teaching with GLOBE but planned to use it in the future and the others said that if they got a chance, they might start using GLOBE again.

The major problems teachers faced in implementing GLOBE was time constraints. Other challenges included lack of equipment, limited resources, fitting with the curriculum, lack of administrative support, and lack of GLOBE training. Some teachers complained that students struggled with analysis and interpretation of graphs. They suggested that students need practice and if these tasks were included in math courses, this issue could be resolved. These are some problems that could be overcome with time, training and efficiency. Other issues included website and internet issues. GLOBE has recently updated its website and has introduced some apps which could be helpful to everyone.

The results also showed that 87.27% of teachers planned to continue teaching with GLOBE activities and protocols and only 12.73% of teachers planned to discontinue teaching with GLOBE activities. The total BARSTL scores for teachers who planned to discontinue using GLOBE ranged from 77 - 97. It was interesting to find out that one teacher with the lowest BARSTL score (76) had stopped using GLOBE in the course she is currently teaching but plans to begin using outdoor GLOBE activities. Two participants with the BARSTL scores of 76 and 77 agreed that GLOBE training had improved their scientific knowledge and had also changed their teaching strategies. Thus, it can be concluded that overall, GLOBE training provides teachers with the confidence to teach science using inquiry. This could help teachers align their teaching beliefs with practice and help improve classroom practices.

5.7 Implications

This study explored teachers' teaching beliefs about GLOBE using inquiry-based activities in the classroom, conducting scientific investigation, and the effect of GLOBE workshops on teachers' pedagogical content knowledge (PCK). The findings of this study contribute to the call from the National Research Council (1996) for teachers to have "opportunities to engage in analysis of the individual components of PCK – science, learning, and pedagogy – and make connections between them" (p. 62). Using the TGTQ and BARSTL together provided teachers the opportunity to think about each of these constructs and provided a rich representation of the teaching beliefs and practices of

GLOBE teachers. This descriptive research study approach, involving both quantitative and qualitative instruments, helped to more accurately explore teachers' perceptions and beliefs in practicing GLOBE activities and investigations in their classrooms and to make comparisons between teachers who are continuing to teach with GLOBE and those who are not.

The results from this study provide evidence that inquiry-based GLOBE activities and investigations could be used to teach science in the way that researchers such as Dewey (1910), Rutherford (1964), and El-Khalick et al. (2004) have advocated. Just as important, inquiry-based teaching is promoted by the most prominent documents in science education including the National Science Education Standards (1996) and the Next Generation Science Standards (2014). The findings reinforce the deep connection between the GLOBE program and the NGSS as delineated by the Iowa Academy of Science and Seavey (2014).

The study provides a model of how BARSTL and TGTQ questionnaires could be used for future studies of GLOBE and useful for GLOBE trainers, master-trainers and educators. The TGTQ and BARSTL could be used in conducting GLOBE workshops as pre-test for prior training and post-test for after training. It could give evidence that GLOBE training would be helpful in implementing hands-on inquiry-based activities in classroom practices. It could help in validating GLOBE as a doing inquiry-based science which could be easily integrated for teaching any discipline of science.

5.8 Limitations.

The first limitation to this study was the population sample. This study was restricted to GLOBE teachers for data collection, and the results of this study would help GLOBE population more than other teachers. An uneven distribution of data may have affected the results. Most of the participating teachers were from public institutions and from the Southeast Region of the U.S. In addition, the topic of this research study was for GLOBE teachers, and some teachers may not have realized the importance of this topic due to time constraints or discontinuity of using GLOBE protocols and activities. A few teachers found this topic sensitive as it is related to pedagogy, especially if they were currently stressed or frustrated with their administration, students, or other GLOBE members entering data into the GLOBE data base. This may have lead some respondents to reply with what they felt was an "ideal" response rather than their personal beliefs. The statistical results of the study may have shown more significant differences if multiple regression was used in place of ANOVA.

5.9 Recommendation for Future Research.

Using a descriptive research study approach to measure beliefs is comparatively new, so there are many possible areas of future study. It is important to continue measuring the teaching beliefs of GLOBE teachers. Extension of this study using a larger, international sample of GLOBE teachers would allow the ideas and conclusions to be further explored. It would then be possible to make comparisons of U.S. GLOBE teachers and those from other countries.

A longitudinal study where the teaching beliefs of a small group of GLOBE teachers could be studied throughout the first five or ten years of their career would allow researchers to begin to answer the question of how teaching beliefs change with age and/or experience.

APPENDIX A – TEACHING AFTER GLOBE TRAINING QUESTIONNAIRE (TGTQ)

Demographics

State: Age in years: 20-30 30-40 40-50 50-60 above 60

Grade level that you teach: Public or Private:

Subjects that you teach: Years of teaching experience:

Globe investigations trained in: Atmosphere, Earth as a System, Hydrology, Land Cover/Biology, and Soil.

Questions:

1. After being trained in GLOBE, estimate your level of use in your classroom:

   Occasionally (sometimes), frequently (often), not any (not at all)

2. Have you stopped using GLOBE in the courses you teach?

   Yes No

   Please explain why.

3. Please explain how GLOBE training impacted your scientific knowledge?

4. Did you change your teaching strategies after learning GLOBE protocols or activities?

   Yes No

   If so, how?

5. How long have you been using GLOBE activities/protocols in class?

   < 1 year 1-2 years 3-5 years 5-10 years > 10 years

6. What are your reasons for integrating GLOBE activities in your teaching?

7. Name certain topics in which you integrate GLOBE activities/protocols.

8. In approximately how many lessons do you incorporate GLOBE during a course?

   1-2, 2-4, 4-6, 6-8, 8-10, 10 or more.

9. Name and describe the GLOBE activity and/or protocol you enjoy teaching the most.

   Please explain why.

10. Do you believe that teaching with GLOBE has influenced your students' learning?

    Yes No

    Please explain briefly.

11. Would you like to implement more outdoor or indoor GLOBE activities?

    Indoor Outdoor

    Please give reasons:

12. How often do you or your students enter data on the GLOBE website?

1X every grading unit, 2X every grading unit, 3X every grading unit, more than 3X every grading unit.

13. What kind of struggles/challenges have you had in teaching GLOBE activities? Please explain.

    (a) Struggles with implementing in class

    (b) Struggles with collecting data

    (c) Struggles with uploading data to GLOBE website

    (d) Struggles with analyzing and explaining data

    (e) Describe any other struggles

14. What kind of successes have you had in teaching GLOBE activities? Please explain.

(a) Successes with implementing in class

(b) Successes with collecting data

(c) Successes with uploading data to GLOBE website

(d) Successes with analyzing and explaining

(e) Describe any other successes.

15. Do accelerated or regular students learn better with GLOBE investigations?

    Regular   Accelerated

    Please explain why.

16. How do you implement GLOBE activities to enrich STEM education in class?

17. How would you convince others teaching any science or STEM course to use the GLOBE Program?

18. Do you plan to continue to use GLOBE activities and protocols in your teaching practices?

    Yes   No

    Please explain how.

APPENDIX B-Belief about the Reformed Science Teaching and Learning (BARSTL)

A.1 How People Learn About Science.

The statements below describe different viewpoints concerning the ways students learn about science. Based on your beliefs about how people learn, indicate if you agreeor disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

1. Students develop many ideas about how the world works before they ever study about science in school.

   SD D A SA

2. Students learn in a disorderly fashion; they create their own knowledge by modifying their existing ideas in an effort to make sense of new and past experiences.

   SD D A SA

3. People are either talented at science or they are not, therefore student achievement in science is a reflection of their natural abilities.

   SD D A SA

4. Students are more likely to understand a scientific concept if the teacher explains the concept in a way that is clear and easy to understand.

   SD D A SA

5. Frequently, students have difficulty learning scientific concepts in school because their ideas about how the world works are often resistant to change.

   SD D A SA

6. Learning science is an orderly process; students learn by gradually accumulating more information about a topic over time.

   SD D A SA

7. Students know very little about science before they learn it in school.

   SD D A SA

8. Students learn the most when they are able to test, discuss, and debate many possible answers during activities that involve social interaction.

   SD D A SA

A.2 Lesson Design and Implementation.

The statements below describe different ways science lessons can be designed and taught in school. Based on your opinion of how science should be taught, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

9. During a lesson, students should explore and conduct their own experiments with hands-on materials before the teacher discusses any scientific concepts with them.

   SD D A SA

10. During a lesson, teachers should spend more time asking questions that trigger divergent ways of thinking than they do explaining the concept to students.

    SD D A SA

11. Whenever students conduct an experiment during a science lesson, the teacher should give step-by-step instructions for the students to follow in order to prevent confusion and to make sure students get the correct results.

    SD D A SA

12. Experiments should be included in lessons as a way to reinforce the scientific concepts students have already learned in class.

    SD D A SA

13. Lessons should be designed in a way that allows students to learn new concepts through inquiry instead of through a lecture, a reading, or a demonstration.

    SD D A SA

14. During a lesson, students need to be given opportunities to test, debate, and challenge ideas with their peers.

    SD D A SA

15. During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.

    SD D A SA

16. Assessments in science classes should only be given after instruction is completed; that way, the teacher can determine if the students have learned the material covered in class.

    SD D A SA

A.3 Characteristics of Teachers and the Learning Environment

The statements below describe different characteristics of teachers and classroom learning environments. Based on your opinion of what a good science teacher is like and what a classroom should be like, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

17. Students should do most of the talking in science classrooms.

    SD D A SA

18. Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.

    SD D A SA

19. In science classrooms, students should be encouraged to challenge ideas while maintaining a climate of respect for what others have to say.

    SD D A SA

20. Teachers should allow students to help determine the direction and the focus of a lesson.

    SD D A SA

21. Students should be willing to accept the scientific ideas and theories presented to them during science class without question.

    SD D A SA

22. An excellent science teacher is someone who is really good at explaining complicated concept clearly and simply so that everyone understands.

    SD D A SA

23. The teacher should motivate students to finish their work as quickly as possible.

    SD D A SA

24. Science teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.

    SD D A SA

A.4 The Nature of the Science Curriculum

The following statements describe different things that students can learn about in science while in school. Based on your opinion of what students should learn about during their science classes, indicate if you agree or disagree with each of the statements below using the following scale:

SD: Strongly Disagree D: Disagree A: Agree SA: Strongly Agree

25. A good science curriculum should focus on only a few scientific concepts a year, but in great detail.

    SD D A SA

26. The science curriculum should focus on the basic facts and skills of science that students will need to know later.

    SD D A SA

27. Students should know that scientific knowledge is discovered using the scientific method.

    SD D A SA

28. The science curriculum should encourage students to learn and value alternative modes of investigation or problem solving.

    SD D A SA

29. In order to prepare students for future classes, college, or a career in science, the science curriculum should cover as many different topics as possible over the course of a school year.

    SD D A SA

30. The science curriculum should help students develop the reasoning skills and habits of mind necessary to do science.

SD D A SA

31. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with "define the problem" and ends with "reporting the results."

SD D A SA

32. A good science curriculum should focus on the history and nature of science and how science affects people and societies.

SD D A SA

APPENDIX C - IRB Approval Letter

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 15110501
PROJECT TITLE: A Study of the Teaching Beliefs of GLOBE Teachers
PROJECT TYPE: New Project
RESEARCHER(S): Laila Ali
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: Center for Science and Math Education
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 11/30/2015 to 11/29/2016
Lawrence A. Hosman, Ph.D.
Institutional Review Board

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