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SCIENCE MUSEUMS, CENTERS AND PROFESSIONAL DEVELOPMENT: TEACHERS' SELF REFLECTION ON IMPROVING THEIR PRACTICE

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ABSTRACT

The purpose of this qualitative case study research was to ascertain the significance of the professional development programs workshops organized by a science museum and a science center in two Midwestern cities. The research investigated the effect the workshops had on the instructional practice of the participating elementary science teachers. More specifically, this study was guided by the following research question: How do the professional development programs at museums help teachers change the way they teach and consider science in their classroom?

The core of this study consists of case studies of six elementary school teachers who were identified as a result of their participation in the museum and science center workshops and an instructor from the museum and another instructor from the science center. Teachers' self-efficacy regarding the teaching of science was sought through a Likert-style survey and triangulated with classroom observations and interviews of individual teachers.

The findings of this study revealed two overarching themes: one, that the workshops were beneficial and two, that it did not improve instructional practice. The following are the factors identified as reasons for the workshops being beneficial: 1) the opportunity to build their content knowledge, 2) opportunity to experience and discuss the materials: 3) opportunity to collaborate with colleagues: 4) workshop materials and resources are linked to state goals: and 5) that they promote teacher confidence. The teachers who thought the workshops did not improve their

instructional practice gave the following reasons: 1) they already had a strong background in science: 2) there was no follow-up activity: 3) the loss of a full day of teaching: and 4) the time constraint to implement what was learned. Though this study utilized a small sample of teachers, those involved in this study felt they acquired knowledge that would be either beneficial to them or to their students and they particularly enjoyed the inquiry-based activities that were conducted in either the museum or the science center workshops.

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CHAPTER 1

Introduction

Informed by earlier research, such as Science for All Americans (American Association for the Advancement of Science [AAAS] 1990, 1993) and the National Science Teachers Association (NSTA, 1989), the goal of the National Research Council (NRC, 2002) standards was to emphasize science education for everyone. According to the reform standards, “scientific literacy has become a necessity for everyone” (NSTA, 1989, p.1). Bybee (2000) noted that though the national goal is to achieve scientific literacy, “this remains a challenge” (p. 45). Fulfilling this goal, Bybee continued, would require collaboration between formal and informal institutions. These informal institutions or free choice education include Science Centers, Museums, Community Outreach programs and Cultural institutions which educate the public outside the regular school setting (Anderson, Lucas, & Ginns, 2003; Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Falk & Dierking, 2000; Hein, 2000).

Research reveals that the elementary school years would be the best time to develop basic science skills in children if we are to encourage science literacy (Albert & Tuomi, 1995; Reinhardt, 1998). Related studies (Jung, 2004; Levitt, 2001) have shown that many teachers feel uncomfortable teaching science as a result of a weakness in their knowledge of science content. The current study explored educational programs in museums and science centers, which can help to improve teachers’ knowledge of science. In an attempt to forge a relationship with schools, many informal settings such as museums and science centers have professional development programs. The visions presented in the National Science Education Standards (NRC, 1996) were for teachers to learn science through inquiry-based experiences. The standards call for programs aimed at encouraging inquiry-based learning, critical thinking and to spark students' interest in the field of science. This can be achieved through sensible professional development that is relevant to changing the instructional practice of science teachers.

Literature reveals that museum and science centers are assuming a dynamic role in the education of children especially as public school budgets continue to decrease (Falk, 2001; Falk & Dierking, 2001; Price & Hein, 1991). Researchers such as Bitgood, Serrell, and Thompson (1994) have stated that the traditional classroom is taking advantage of museums as informal learning environments. There is an increase in the number of schools turning to science centers, museums and zoos for the education of students (Price & Hein, 1991). These studies (Bitgood et al. 1994; Cox-Petersen, Marsh, Kisiel, & Melber, 2003; Dierking et al., 2003; Falk, 2001; Falk & Dierking, 2001) suggest museums provide experiences and resources that encourage hands-on learning and enhance creativity among elementary school children.

These centers not only afford students the opportunity to gain meaningful experiences, but can also make available to teachers the necessary professional development opportunities critically needed to improve their science content knowledge and thus their teaching. Melber and Cox-Petersen (2005) suggest that workshops offered by museums and science centers help teachers improve their instructional methods and help them learn about the resources available in their communities. This may have been as a result of the emphasis placed on professional development by the federal government in the *Goals 2000: Educate America Act* (U.S Department of Education, 1994). In their studies about professional development and school reform, Darling-Hammond and McLaughlin (1995) suggested “the nation’s reform agenda requires most teachers to rethink their own practice, to construct new classroom roles and expectations about student outcomes” (p. 5).

Brief History of the Study

In response to the widespread national dissatisfaction with the quality of the nation’s educational system and the need to improve the country’s preparedness to compete internationally, the National Commission for Excellence in Education was inaugurated in 1981 by the then secretary of Education, Terrel Bell. The job of the commission was to examine the quality of education in the United States. The commission’s findings were documented in *A Nation at Risk: The Imperative for Educational Reform* published in 1983. Among other things, the report found that, “Despite widespread publicity about an overpopulation of teachers, severe shortages of certain kinds of teachers exist: in the fields of mathematics, science, and foreign languages and among specialists in education for gifted and talented, language minority, and handicapped students” (National Commission on Excellence in Education, 1983, p. 6). The report went on to point out that, “The shortage of teachers in mathematics and science is particularly severe” (p. 5). A survey conducted in 1981 of 45 states revealed shortages of mathematics teachers in 43 states, critical shortages of earth science teachers in 33 states, and of physics teachers everywhere. While the above observations have direct impact on the quality of science education imparted to students, the pedagogical strategies of teaching employed in the teaching of science also have significant effects on learning outcomes for students.

Twenty years after the *Nation at Risk* report deplored the state of America’s educational system, more reforms have been proposed to address the deficiencies that still affect the teaching of science. Many American schools still lack much needed resources to meet educational standards (Howard Hughes Medical Institute, 1995). One such call for more reforms was introduced in 2001 under the *No Child Left Behind* act by the federal administration. The aim was to solve the same educational issues identified by the *Nation at Risk* report, which focused on the poor performance of American students compared to international students. The report complained of schools not offering a challenging curriculum (The White House, 2007). It also called for partnership programs with higher education institutions and other community programs to strengthen science education in elementary schools. The goal was to improve the increasing participation of students in science and mathematics. These reforms remind us of the continued call for how the teaching of science can be improved. In light of this, the National Science Education Standards (NSES) published by the NRC (1996) have suggested that teachers need to be given resources and other opportunities to change their instructional strategies that would in turn support the quality of science teaching. Following the suggestion of NSES, the present study focused on how professional development programs offered by museums and other science centers can provide the resources teachers need to change their instructional practice.

Statement of the Problem

As *A Nation at Risk Report* (1983) and the *No Child Left Behind* (2001) act indicate, the teaching of science needs improvement. The attainment of science literacy is more than memorizing formulas and charts; it needs to help students understand the environment around them. A survey by the National Center for Educational Statistics (NCES, 1995) revealed that a large percentage of elementary school teachers did not major or minor in science during their college days. How then can they be expected to teach science effectively to students? The problem, according to research, can be solved through extensive professional development (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Weiss, Banilower, McMahon, &

Smith, 2001). There is still the question of how research can improve the teaching and learning of science in the nation's elementary schools. In all countries of the world, science, according to Asoko (2000), is becoming an important aspect of elementary school curriculum.

Despite the importance of science, students are not being provided with science experiences that are meaningful to them. It has also been documented that teachers lack the subject knowledge and sometimes the resources to direct students to attain meaningful scientific inquiry (Abd-El-Khalick & BouJaode, 1997 as cited by Jung, 2004). Lack of these resources have in turn led to avoidance of science topics not covered in science textbooks they were provided.

If teaching of science is to be improved, teachers need to fully utilize informal science learning resources available in their communities. Though many studies have documented the problems associated with the teaching of science (Abd-El-Khalick & Lederman, 1998; Brickhouse, 1989, 1990; Duschl & Wright, 1989; Gallagher, 1991; Lederman & Zeidler, 1987), very few have identified the potential resources science centers and science museums can provide. Empirical literature is also limited in terms of identifying how well aligned these professional development programs are with the needs of teachers. This study therefore focused on how these institutions can actively be involved with teachers to provide the inquiry-based experiences needed by students.

This study examined the professional development programs offered by science centers and museums. This is in recognition of the gap in available literature on the active role of science centers and museums. It also focused on the reflections of teachers who attend these programs and how attending the professional development programs have made any difference in the way they teach science in the classroom. The specific research question that guided this study is:

How do the professional development programs at museums help teachers change the way they teach and consider science in their classroom?

Purpose of Study

History has shown that there has been a continued concern for the need to improve the teaching of mathematics and science in American schools. The demand to effect this change is placed on the teacher to provide science instruction that is effective (Duschl, Schweingruber, & Shouse, 2007). This has seen significant efforts by researchers to bring about change in the classroom (Anderson, & Helms, 2001; Davis, 2002). However, there is the acknowledgement that change is difficult (Davis, 2002). Yet, there is the need to take a look at reform efforts that would assist teachers to change the way science is taught in elementary schools. This study examined how museums and science centers educational programs are important to the field of science education. With evidence from the research literature, this study showed what others have suggested about the need for re-inventing teacher professional development (Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Sparks & Hirsh, 2000; Sykes, 1996). Professional development, Sparks and Hirsh (2000) suggested, is aimed at improving student performance and teacher training. The study attempted to fill the gaps in the knowledge base of how teachers of elementary science can be assisted to improve their instructional practice.

Through the *Nation at Risk Report* and the *No Child Left Behind* act, leading school reformers have been calling for changes in the way mathematics and science are taught in elementary schools (NCEE, 1986). Jung (2004), in discussing the work of Thomas Huxley, emphasizes the need for science to be taught in a way that would encourage children to experience their world. Bybee and Deboer (1994) and Alberts (2000) note that this process involves students having the freedom to investigate and to have direct contact with their physical environment. To encourage that process of discovery among students, Perpich (1995) pointed out that science museums and other such institutions can help children learn science in a way that would affect their educational progress. Science museums, he further noted, can act as a bridge between their school experience and what they need to develop a positive relationship with science. These centers not only provide hands-on learning experiences, they also inspire students to use their different learning styles and promote self-paced learning.

Inquiry-Based Learning

This study hopes to strengthen the need for inquiry-based activities that would encourage teachers to teach their students to gain knowledge through methods that involve theory, observation and hypothesis. Central to the goals proposed by the American Association for the Advancement of Science (1993) is the promotion of scientific inquiry. Inquiry provides students the skills necessary for problem solving and critical thinking (Alberts, 2000; Paris Yambor, & Packard, 1998). Scientific inquiry will help nurture the curiosity and scientific reasoning of students. This in turn will improve their thinking skills and ability to solve scientific problems.

Scientific inquiry involves applying critical thinking, discovery learning, and exploration. There is a general consensus among researchers that early exposure to the inquiry- based method of teaching instead of the traditional way of memorizing formulas would convey the message that science can be exciting (Perpich, 1995). Inquiry-based teaching involves posing questions that demands investigation and also requires the teacher to have excellent knowledge of the content. Perpich (1995) asserts that science centers and museums offer supplementary resources, and flexible learning environments that correspond to reform methods. Studies also show that in traditional classrooms, teachers present facts that often do not encourage the active participation of students (Asoko, 2000; Stein, 2006). This method only encourages students to memorize facts without a true scientific understanding. This is contrary to what modern reforms call for in the teaching of science in elementary schools.

A theoretical framework that supports a way of knowing through inquiry-based learning is constructivism. Though not a new concept, Von Glasersfeld in 1989 tried to apply the concept of constructivism to educational problems (Tobin, Tippins & Gallard, 1994). It is defined as a set of beliefs that perceives learning as a social process of making meaning. Inquiry-based learning from a constructivist point of view should enable students to construct their own meaning. Meaning making can be through appropriate experiences coupled with teachers acting as facilitators. Partnerships between schools and science museums will provide access to inquiry-based learning that reformers seek. Programs offered by these out-of-school institutions will provide the hands-on laboratory experiences (Paris et al. 1998, Perpich, 1995, Tobin et al. 1994).

Teacher's Beliefs and the Teaching of Science

One cannot discuss implementing change in teachers' instructional practice without mentioning teacher beliefs. These beliefs include but are not limited to, how students learn; the learning process; curriculum and about their responsibilities (Levitt, 2001). It has been seen as an important factor in determining why elementary school science is not being taught the way it should be. Literature reveals that the beliefs and attitudes of teachers are very important in teachers wanting to change their pedagogy (Ramey-Gassert, 1993). Wasley (1991) found out through her work with teacher leaders, that if given the opportunity to collaborate with other teachers in a growth-oriented setting, their teaching would improve.

Studies show that elementary school teachers feel uncomfortable teaching science. Citing Stake and Easley, Ramey-Gassert (1993) stated that "teachers view science as a subject, something they had to take in college" (p. 2). As a result, this has led to the failure of teachers to see science as a creative inquiry. Ramey-Gassert emphasized that this makes elementary teachers feel they are not well prepared to teach science effectively. Thus, improving teachers' instructional practice has been a major concern of educators, administrators and the community in the past two decades. Yet little attention, according to Loucks-Horsley and Stiegelbauer (1991), has been paid to teachers who have been called to make overnight changes to their instruction. Thus, the goal of this study was to take a critical look at museums and science centers that have teacher development programs and how the needs of teachers can be met. Research also indicates that inadequate preparation at the pre-service and in-service level has created elementary teachers negative attitude to science or not wanting to teach science at all (Jung, 2004; Stein, 2006). In further discussion of teachers' beliefs towards science teaching, Ramey-Gassert (1993) used Bandura's theory to explain that self-efficacy beliefs are based on previous experiences.

Therefore, maintaining a sustained change in teachers' practice requires more than changing classroom practice. It should comprise of a "different way of thinking about science, including the teaching and learning of science" (Levitt, 2001, p. 1). In discussing the study conducted by Bybee (1993), Levitt (2001) stated that successful change depends on a teacher's ability to merge a new philosophy to their own existing philosophy. In other words, a teacher's beliefs have to be aligned and adapted to any educational program before it can be implemented.

In their work with Concerns-Based Adoption Model (CBAM), Loucks-Horsley and Stiegelbauer (1991) came up with different perspectives about change. The authors noted that policy makers need to know that "change is a process not an event" (p. 17). Taking this into account, it would be absurd to expect teachers to abandon what they know to be true practice for a new program as soon as they are told to do so. To effect any change teachers require support, one aimed at facilitating change. Professional development programs must also take into consideration the "development process of change" (p. 18) that addresses the needs of their participants and makes it a continuous process and not just a one-day seminar. The professional program providers, therefore, have to be in constant contact with teachers instead of expecting them to go through the change process alone. To effect any change in the way science is taught in elementary schools, teachers must examine their own beliefs and how it can fit into new science reforms recommended by National Research Council (1996).

Need for Study

Studies have shown that there is a growing interest about the relevance of museums and science centers in relation to the teaching of science (Dierking, 1991; Gardner, 1991; Ramey-Gassert, Walberg & Walberg, 1994; Resnick, 1987). Existing literature points to the relevance of out-of-school settings such as museums, science centers, zoos and aquariums to the attitude of students towards science learning (Dierking, 1991; Gardner, 1991; Ramey-Gassert et al., 1994; Resnick, 1987). There have also been studies about teacher efficacy (Ramey-Gassert, 1993) and research on school fieldtrips to science museums (Anderson & Lucas, 1997; Bitgood, 1994, Kisiel, 2006). However, there is limited literature in the area of museum professional development programs that focus on improving the way teachers teach science in elementary schools. This study explored how out-of-school resources in museums and science centers can provide meaningful in-service experiences to teachers, which can help them to gain quality science skills and improve their practice. It also attempted to provide an insight into the level of commitment by a museum and a science center in a Midwestern state to expand their science content knowledge through the programs offered to teachers. In so doing, teachers in this region would learn about the resources available in their communities to improve their instructional methods and practice.

Significance of Study

Educators today are asking if the skills children acquire in American schools would prepare them to compete globally with other world economies. Results of this study will inform educators as to how the programs offered by museums and other science centers can help shape the way science is taught in elementary schools. The information can also be used by school administrators to collaborate with these out-of-school institutions to improve science teachers' instructional practice. It will also assist science museums and institutions to recognize the importance of their role in the education of American children. Marshall and Tucker (1992) noted that students need the ability to think abstractly, and experience inquiry-based skills. Research also shows that adequate knowledge of science is a teacher's main tool in helping students learn science (Duschl et al., 2007). The authors argue that "currently K-8 teachers have a limited knowledge of science" (p. 296). These skills can only be provided through science education, which focuses on the unique opportunity to motivate students based on hands-on experience in an informal museum setting (Howard Hughes Medical Institute, 1995). Sustainable professional development is needed to overcome inadequate science content or science teaching self-efficacy of K-8 teachers currently in service.

Museums have the potential to augment in-service training and provide resources for teachers. Since science is not one of the core subjects tested in the early grades, experience has shown that most school districts' curricula have narrowed to focusing on reading and mathematics in order to pass state standardized tests (Penna, 2007). This practice has placed limits on the kinds of experiences students and teachers have in school. Penna (2007) suggested that it is important for schools to look outside the school environment for resources that can help teachers improve the science learning experiences that students have, experiences much needed for them to learn about their natural environment.

According to the standards drafted by the National Research Council (1996), science teachers need help planning inquiry-based programs for students, and to design lessons that involve students interactively with their environment. As Weiss et al., (2001) rightly stated,

> what happens in the classroom depends on what science teaching activities and content knowledge teachers bring and the support they are offered. Thus, to improve science education in American elementary schools, teachers should be offered the opportunity to improve their teaching through school-museum collaboration. This can be achieved with the programs museums and science centers offer teachers through workshops or other professional development activities. The experiences acquired through these programs would help "deepen understanding of what they teach. (p. 51)

Museums can therefore provide real-world experiences that will aid teachers to understand the true nature of science.

Calls for reform require teachers to change their practice. However, as Cohen and Ball (1990) noted, change is difficult, "And changing one's teaching is not like changing one's socks" (p. 334). Changing the way one teaches requires a professional development that cannot be done in just one summer workshop, it has to be an on-going process. We must remember that, teachers who participate in in-service have many years of constructing their own way of teaching that involve their own personal beliefs and experiences. It is not something that can be changed in one sitting (Harris, 1997).

The objective of any professional development program as suggested by Gall and Vojtek (1994) should be to improve teachers' professional skills and most importantly to encourage authentic learning. They also went on to state that any good professional development should take into consideration the need for teachers to enhance their teaching and make a difference in the lives of their students. According to Sparks (1988), this can be achieved through a program that is structured, encourages small-group sharing and problem solving sessions (as cited in Gall & Vojtek, 1994).

The answers to the research question in this study are intended to assist museums recognize programs most relevant to teachers and the ever changing curriculum. It also highlights community resources available to teachers in the school districts in this Midwestern state. The answers will aid teachers to form partnerships with available science centers and museums, to develop their curriculum and provide other out-of-school opportunities for students to effectively gain scientific knowledge and to interact with the environment.

Answers to the research question also provide museums and science centers the opportunity to examine the programs they offer and to make visits to centers more engaging for students and teachers alike. It will also help them examine the significant role informal science learning settings play in providing teaching tools in the science education of elementary school children.

Overview of Methodology

This study provides an in-depth study of a museum and a science center. This research study adopted a case study qualitative research methodology to investigate how a museum and a science center use their teacher professional development programs to change the way science is taught in schools. A qualitative collective case study was used to investigate the effect of museum professional development programs on the classroom experiences of six science teachers. This kind of design allowed for a detailed natural examination of the research question. A case study method also allowed for investigation of what Creswell (1998) called “detailed, in-depth data collection involving multiple sources of information rich in context” (p. 61). A case study approach was necessary to explore the complex phenomena where boundaries within contexts are not obvious and multiple data sources are required for triangulation and is entrenched in the real world (Gillham, 2000; Yin, 2003). The study examined how museum professional development programs attended by teachers can help improve their instructional practice with regard to teaching inquiry-based science instruction. Museum science education and professional development for classroom teachers is a new phenomenon that has not been fully researched. This is especially true in the case of how teachers who attend these programs feel about them. Literature shows that research has only focused on how museums educate the general public through fieldtrips, and family museum visits (Falk, 2001; Falk & Dierking, 2000, 2002; Hein, 2002; Jung, 2004; Kisiel, 2003). By focusing on the perspectives of science teachers attending the professional development programs, this research is aimed at adding to the body of research that will address this issue.

Definitions of Terms

Nature Center – An establishment for the outdoor learning of nature, including a site for school fieldtrips.

Science Center- A facility that offers hands-on experience opportunities aimed at school-aged children.

Science Museum- A museum devoted to the field of science.

Limitations

This study was based on teachers' beliefs or self-efficacy of how science can be taught in order to improve students' scientific experiences. It was also based on the assumption that professional development programs organized in informal settings such as science centers and museums are relevant to the teaching of science in elementary schools. It is also assumed that teachers may not honestly provide answers to survey questions about the teaching of science and about their professional needs. On the other hand museums and science centers may identify professional development needs that may not be in the best interest of teachers. Another major limitation to this study that should be noted is that change takes time and this research had a 3-4 month time constraint.

Delimitations

This study was limited to teachers participating in professional development programs conducted by informal settings such as one science center, and one science museum in two Midwestern cities. The data were gathered from interviews with and survey of six teachers who participated in these centers' workshops. The conclusions are not generalizable and should not be considered as a representation of elementary schools in the United States.

Assumptions

The assumption of this study is that data collected from a qualitative case study was appropriate to determine the influence of museums and nature centers in the teaching of science. It was assumed that teachers interviewed truthfully and accurately responded to what they think about science centers and museums. Another assumption was that science centers and museums visited accurately shared the programs they offer and documents to show that their programs do influence the way science is taught in the elementary schools. It was also assumed that the sample population would be representative of a larger population. Therefore, the overall assumption is that the findings for this small sample would contribute to scientific research on the significance of nature centers and museums on science teaching and learning.

Summary

The intention of this study is to address certain problems that exist in the teaching of science in elementary schools. The observations and interviews that were conducted about the programs provided by the science center and museum shed light on the types of teaching necessary to empower children to learn. It also emphasized the capacity of science centers, museums and other similar institutions to assist teachers in developing inquiry-based instruction for students that will in turn encourage learning through explorations and community involvement in science education. This study also recognizes that teachers cannot solely rely on textbooks to improve students' performance in science.

CHAPTER 2

Literature Review

Museum Professional Development Programs and the Teaching of Science

It has been established in the literature that teachers' views about the nature of science affects the way they present science to their students (Fraser-Abder, 2002). This argument is supported by Darling-Hammond and Sykes (1999) who stated that increased student learning can be achieved through teacher learning. Therefore, there have been calls for more professional development opportunities that will help teachers solve authentic problems and in turn improve their knowledge of science (Hawley & Valli, 1999, as cited in Fraser-Abder, 2002). This chapter focuses on the theoretical framework of this study that emphasizes science teacher beliefs and the professional development programs provided by science centers and museums. To better understand the impact of museums on the teaching of science in elementary schools, it is pertinent to mention teachers' belief in science. As stated in Chapter 1, there have been growing concerns about improving K-12 education in the United States. This is especially true in the area of science and mathematics. In order to improve the teaching of science, the attitudes and beliefs of science teachers about science need to be improved. Over the years there have been many initiatives on how to improve the teaching of science, especially in elementary schools. It has been acknowledged that science teachers in elementary schools are deficient when it comes to the science area content (American AAAS, 1993; NRC, 1996). This has been the result of lack of confidence to teach science and inadequate preparation of teachers in science as a subject. Literature relevant to this research study falls into different categories. There are a number of empirical studies that have contributed to the theoretical framework of this study. The studies focus on the acquisition of scientific knowledge of elementary school teachers and thus provide a knowledge base to which this study contributes. Calls for reform in our nation's schools have led researchers to seek a variety of avenues that encourage emotion-laden experiences that will help improve attitudes of teachers towards science and how children are taught science in elementary schools (Anderson & Helms, 2001; Davis, 2002; Falk & Dierking, 2000; Lieberman, 1995; Sykes, 1996).

This chapter focuses on the reasons why science is not being taught well in elementary schools. Whereas research has primarily focused on the importance of science centers and museums in the teaching of science, there are very limited studies on how collaboration of science centers, museums and schools can improve teacher's attitudes towards science (Cox-Petersen et al., 2003; Falk & Dierking, 2000, 2002; Hein, 2000; Jung, 2004; Kisiel, 2003; Ramey-Gassert, 1997; Rennie, Feher, Dierking & Falk, 2003). Literature shows that teachers teach science the way they were taught, through lectures and note taking instead of hands-on-experiences (Jung, 2004). It is also shown that students learn well when they are able to construct their own learning through engagement in hands-on activities. This is, however, lacking in most elementary science classrooms across the United States.

Literature also suggests that there are alternative out-of school settings that provide hands-on activities that students need to construct meaning in science (Asoko, 2000; Bitgood et al., 1994; Falk & Dierking, 2001; Jung, 2004). Museums and science centers are therefore valuable community resources available to teachers that provide a new way of teaching science that will be beneficial to students. The chapter also looks at out-of school science settings and provides a framework of how these centers help change the perceptions of teachers and the way they teach science to elementary school children. The use of science centers and museums has been researched (Falk, 2001; Falk & Dierking, 2000; Hein, 2000) but the collaboration of schools and these centers to improve the teaching of science has been minimally researched.

Theoretical Framework

There is a belief that informal learning or free-choice learning settings follow basic constructivist theory. The constructivist believes that learners actively construct their own meanings through a generative process. Falk and Dierking (1992, 2000) suggest that learning occurs through interactions with peers and teachers and is then filtered through one's experience and prior knowledge. According to Falk and Adelman (2003) students create new understandings and attitude towards learning through the successful interaction of their prior knowledge and new experiences in a physical environment such as museums and nature centers. Griffin (1998) noted that both the physical and social environment determines what students learn. Using Vygotsky's learning theory Griffin stated that children's understanding is development through their experiences based on engagement and discussion with other people. Vygotsky believes that when people interact through conversation, their experiences are pooled together to attain a higher level of understanding (Griffin, 1998). Semper (1990) also noted that learning which takes place in museums is 'multi-sensory' and supports different learning styles. This approach to learning reinforces Howard Gardner's multiple intelligences. According to Gardner (1992) there are multiple ways of learning and he categorized these ways as linguistic, spatial, logical, bodily kinesthetic, visual, musical, interpersonal and naturalistic. There are many programs in museums and other science centers today that reinforce these different kinds of learning experiences. Theoretical and practical implications of these findings for teachers and students in museums and nature centers will be discussed.

While Feher and Diamond (1990) has observed that research into learning informal or free choice settings was in its formative stage, Ramey-Gassert et al. (1994) as cited in Anderson et al. (2003) noted that much of the literature discussing learning in museums was not theoretically clear. Learning in museums and other such institutions can be explained with the constructivist's view of learning. It is recognized by many researchers (Feher & Diamond, 1990; Hein, 1995; Lucas et al., 1986 as cited by Anderson et al., 2003) that prior knowledge and the individual construction of meaning from museum experience are very important. The most appropriate theoretical framework that can largely answer the research question of the effect of learning in museums on students and the way teachers teach science is the human constructivist theory. Human constructivist theorists view learning as the ability of individuals to use their current conceptions as products of the many personal experiences such as observation at museums coupled with explanations from the teacher. Thus, according to Griffin (1998), the role of the teacher in a constructivist learning environment is that of a facilitator. Since learning cannot be forced on anyone, it can be facilitated by a range of experiences being presented to students. Teachers and students in this case need to be partners in the learning process. In other words, students should be given the opportunity to have some control over their own learning (Anderson et al., 2003). Learning according to human constructivists as noted by Anderson et al. happens at different rates, can be assimilative, gradual or rapid and are all based on how individuals perceive what is learned. Human constructivist theory is important to this research because it would serve as a potential guide to understanding how individuals' prior knowledge and their active participation in museums and other institutions can help them construct meaning.

Hein (1998) also pointed out that constructivist theory is the most reasonable in explaining the interaction that takes place in a museum.

The construction of meaning in this case depends on the teacher's ability to restructure the knowledge gained from the museum when they return to the classroom. For teachers to capitalize on the experiences students acquire from a museum and other similar institutions, they must provide the opportunities to present their accounts of what was actively learned and understood in these stimulating environments. Teachers should probe students through the use of open-ended questions as part of their instruction that would help students relate previous experiences to their everyday lives. This will help children discover their prior knowledge and the knowledge gained as a result of the museum or nature center visit (Anderson et al., 2003).

The process of gaining scientific knowledge is also a social and individual process. The cognitive and social benefits of the experiences students encounter in museums and other similar institutions have been well recognized by Falk and Dierking (1992). They see museums as highly stimulating physical and social environments for learning. Is it necessary to make a distinction between the learning that occurs in formal settings such as schools and informal settings like museums and nature centers? Dierking (1991) argued that making a distinction is inappropriate since "learning is learning, and it is strongly influenced by certain social interaction and individual beliefs, knowledge and attitudes2" (p. 4). Anderson et al. (2003), in citing Hofstein and Rosenfeld (1996), stated that researchers of science education in the future should focus on how learning in informal and formal settings can be blended to create a significant learning experience that will in turn enhance inquiry based learning of science.

Inquiry-based Science Teaching

In the *National Science Education Standards* document (NRC, 1996) inquiry in its content is defined as:

> Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries. (p. 23, as cited in Wheeler, 2000)

Wheeler identified in his article, *The three faces of inquiry,* that the role of the teacher changes when inquiry is expected from the content students are expected to learn. Why inquiry and what does an inquiry-based classroom look like? Since the late 19th century, when science began to be discussed in the field of education, theorists and educators such as Eliot, Dewey, Schwab and Rutherford (Bybee, 2000) saw the need for science to be taught as a method of inquiry. Bybee went on to recognize the contribution of *Project 2061.* This was a project inaugurated by Rutherford in 1985 as a long-term initiative of the American Association for the Advancement of Science (1993) to reform K-12 education. The goal of this initiative was to recommend what students need to do in their early years of schooling. The following recommendations were made: Start with questions about nature, engage students actively, concentrate on the collection and use of evidence, provide historical perspectives, insist on clear expression, use term approach, do not separate knowing from finding out, de-emphasize the memorization of technical vocabulary (Bybee, 2000). This process, according to Bybee, set the stage for science reform that includes teaching science inquiry as content.

Alberts (2000), president of the *National Academy of Sciences*, described inquiry as “struggling to meet a challenge in which one’s own initiative is needed to acquire an understanding” (p. 4) He suggested teaching science as an inquiry-based, involves allowing children to imagine a problem and then think of solving that problem through scientific discovery. Minstrell and Van Zee (2000) went on to point out that some teachers think inquiry means finding a teaching strategy that engages students in hands-on activities. They noted that using engaging activities in the classroom is important but it is not enough. Emphasis, they suggested, should to be placed on situations that allow students to practice dialogues in the scientific way of learning. Dialogue in this case is directing students to question what they are doing. Research also suggests that inquiry- based learning provides skills students need to communicate, problem-solve and think (Alberts, 2000). Alberts (2000) went on to recommend that learners should be able to reason like scientists by carrying out experiments that tests ideas, as this is more rewarding to students than the traditional instruction of the teacher doing all the thinking and demonstration. Discussing the benefits of inquiry-based learning, Alberts stated “properly constructed inquiry in education motivates students…it confronts them with an unknown puzzle, which can be solved only by a process that involves risk taking” (p. 5-6).

The question, however, is all hands-on activities inquiry-based activities? Wheeler (2000) does not think so because as he stated, the fact that children are seen with materials does not mean there is any understanding taking place. A true inquiry-based activity, according to Wheeler is an activity where children are given the opportunity to ask questions, as they interact with materials. In addition, Wheeler also recognizes the importance of dialogue by stating that a true inquiry-based activity is one that encourages dialogue through questioning, observation, predicting and reflection.

In defining what all students need to know and be able to do and the kind of learning experiences they need to achieve scientific literacy, the *National Science Education Standards* (NRC, 1996*)* presented the following understandings about scientific inquiry:

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanation is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.

- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations (NRC, 1996 p. 236).

Although inquiry is an essential component of science learning, little is known about elementary school science teaching as inquiry-based.

Science Efficacy, Attitude and the Teaching of Science

The lack of confidence in the attitudes of teachers in the teaching of science, according to research, is a major factor that has affected the way science is taught in elementary schools in the United States today. Jung (2004), in citing Ferry (1995) and Ramey-Gassert et al. (1996), describes science teaching efficacy as “one’s belief in his/her ability to teach the subject of science.” (p. 25). Based on Bandura’s work on self-efficacy, Ramey-Gassert et al. describe two aspects of science teaching self-efficacy that are personal science teaching efficacy and the science teaching outcome. In their discussion it is clear that both aspects share the same variables, though personal science teaching efficacy influences student outcomes. The authors also looked at the factors that influence the way elementary school teachers teach science. They found the factors contributing to exemplary science teaching require a rich complex explanation. An extensive literature review was conducted by Ramey-Gassert et al. to look for factors that influences self-efficacy which they discovered to be early science experiences (informal and formal school experiences), prior life and professional development experiences and attitudes towards science. Jung, in discussing Ramey-Gassert et al., found that there are several factors influencing science teaching efficacy development. One such factor is the prior experiences teachers have had with science. This factor has been found to contribute to the attitudes of teachers choosing to teach science or not. Jung cited Ramey-Gassert et al. as describing this factor as “behavioral manifestation of science teaching self-efficacy” (p. 26). Another factor identified by Ramey-Gassert et al. was interest and desire for personal growth in the teaching of science. Their study revealed that teachers with high personal science teaching efficacy tended to be more active, while those with low personal science teaching efficacy seem to have had negative experiences in science and usually do not look for new science activities. They also reported that teachers who do not feel they have sufficient knowledge about science avoid teaching science. Again in discussing the study done by Ramey-Gassert et al., Jung stated that science teaching efficacy is an area that has been overlooked in science reform efforts. Existing literature suggests that increased science efficacy may result in the improvement of the teaching of science in elementary schools.

In another study, Stein (2006) stated that developing self-efficacy and self-confidence among elementary school teachers might motivate them to teach science. This, he also noted, increases teachers’ positive attitude towards choosing to teach science and being comfortable with the subject matter.

Teacher’s beliefs and the teaching of science. One cannot discuss implementing changing teacher efficacy without mentioning teacher beliefs. These beliefs include how students learn, the learning process, the curriculum and teachers’ beliefs about their responsibilities (Levitt, 2001). Teachers’ beliefs has been seen as an important factor in determining why elementary school science is not been taught the way it should. Existing research point out that, beliefs and attitudes of teachers are very important in teachers wanting to change their pedagogy. Wasley (1999) found out in her study of teachers in the Coalition of Essential Schools, that if given the opportunity to collaborate with other teachers in a growth-oriented setting, their teaching improved.

Studies show that many elementary school teachers feel uncomfortable teaching science. Citing Stake and Easley (1978), Ramey-Gassert (1993) stated “teachers view science as a subject, something they had to take in college” (p. 2). As a result, this has led to the failure of teachers to see science as a creative inquiry. Ramey-Gassert emphasized that this makes elementary school teachers feel they are not well prepared to teach science effectively. Thus, changing teachers’ instructional practice has been a major concern of educators, administrators and communities the past two decades. Yet little attention, according to Loucks-Horsley and Stiegelbauer (1991), has been paid to teachers who have been called to make overnight changes to their instruction. Thus, this study takes a critical look at museums and science centers that have teacher development programs and how the center meets professional needs of teachers. Research also indicates that inadequate preparation at the pre-service and in-service level has created elementary teachers negative attitude to science and their fear of teaching science (Jung, 2004; Stein, 2006). In further discussion of teachers’ beliefs towards science teaching, Ramey-Gassert used Bandura’s theory to explain that self-efficacy beliefs are based on previous experiences.

Maintaining a sustained change in teachers’ practice requires more than changing classroom practice. It should comprise of a “different way of thinking about science, including the teaching and learning of science” (Levitt, 2001, p. 1). In discussing the study conducted by Bybee (1993), Levitt stated that successful change depends on a teacher’s ability to merge a new philosophy to their own existing philosophy. In other words, a teacher’s beliefs have to be aligned and adapted to any educational program before it can be implemented.

In their work with Concerns-Based Adoption Model (CBAM), Loucks-Horsley and Stiegelbauer (1991) came up with the different perspectives about change. The authors noted that policy makers need to know that “change is a process not an event” (p. 17). Taking this into account, it would be absurd to expect teachers to abandon what they know to be true practice for a new program as soon as they are told to do so. To effect any change teachers require support, one aimed at facilitating change. Professional development programs must also take into consideration the “development process of change” (p. 18), which addresses the needs of their participants and makes it a continuous process and not just a one day seminar. They, therefore, have to be in constant contact with teachers instead of expecting them to go through the change process alone. To effect any change in the way science is taught in elementary schools, teachers must examine their own beliefs and how it can fit into new science reforms recommended by National Research Council (1996).

Teachers’ attitude towards science. As indicated above, teachers with negative attitudes towards science most often do not teach science in their classrooms. Research on the attitudes about the teaching of science was prevalent in the mid-1970s literature. Though research about attitude has been carefully documented in formal school settings, literature is however limited in informal or free choice educational settings (Chesebrough, 1994).

Science attitude can be described as a person’s attitude about science as a subject. Sometimes a teacher’s attitude can be assumed to be the time he or she spends in teaching science or the manner in which the subject is taught (Jung, 2004; citing Ferry, 1995). The term attitude according to Koballa (1988) can be used to represent people’s belief, opinion value or belief. He, however, cautions about the notion that a person’s beliefs influences their attitude. In arguing about pre-service teachers, Koballa noted that the positive attitude towards science does not necessarily mean competent teaching or vice versa. He suggests that for science to be taught in an effective way a teacher must have the right attitude. Koballa pointed out that there are mixed results in studies relating to science attitudes. Since the results of these studies are indecisive there is little contribution to the topic. It is, however, important to study science attitude because it has been found to influence science efficacy.

Existing studies also suggests that when elementary teachers have negative attitudes towards science, it leads to less teaching of the subject (Westerback, 1982). This negative attitude Westerback went on to argue affect students' learning as they pick up on the attitude of their teachers. Koballa and Crawley (1985), however, warned that it cannot be assumed that students will have a positive attitude about science even if they learn more science. Conversely, Ramey-Gassert (1993) found in her study that elementary school teachers' efficacy correlated with their enthusiasm to teach the subject. Ramey-Gassert et al. (1994) found that field trips to science centers positively increased students' attitude towards science because they provide real world connections to science while using new technology.

Literature on professional development and science teaching. A review of the literature on professional development shows that the major challenge to school reform is effective teachers' professional development (Darling-Hammond & McLaughlin, 1995). The NRC (2002) cited Wilson and Berne (1999, p. 174) as stating that there are many ways and context in which professional development opportunities are presented to teachers. Before going further, it is imperative to define professional development. According to Kent (2004) "it is the process of improving staff skills and competencies needed to produce outstanding educational results for students, as teachers are becoming the centerpiece of educational change" (quoting Hassel, 1999, p. 427). Kent went on to state that professional development is what teachers need to stay motivated and to stay "current in best teaching practices" (p. 428). Yet, according to Darling-Hammond and McLaughlin (1995) and Loucks-Horsley et al. (2003) these programs are not presented in a coherent fashion to teachers. As a result, teachers do not benefit from professional development programs.

The literature also show that there are major discrepancies between what is known as effective professional development and what is actually experienced by science teachers (NRC, 2002). An in-depth study of the literature also reveals that like students, teachers learn best by being actively involved, and reflecting on what they have learned and learning science through inquiry (Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Loucks-Horsley et al., 2003; Speck & Knipe, 2005; Yager, 2005). Opportunities therefore need to be provided to science teachers to support their professional growth while at the same time challenging them to change and reflect on their practices (Speck & Knipe, 2005).

These science experience opportunities according to studies are being initiated by informal science education centers such as science museums, zoos, nature centers and botanical gardens (Melber & Cox-Petersen, 2005). In their study of three different models of professional development workshops provided by a natural history museum, they found that many opportunities were provided to the participating elementary school teachers to "enrich their scientific content knowledge" (p. 103). However, it should be noted that studies assessing the extent of the impact these informal settings such as museums have on changing the teaching practice of teachers is limited.

Researching museums and science centers in the teaching of science. The literature relevant to this study primarily uses the term informal or free choice learning school settings to refer to science centers and museums. The term "informal" or "free choice learning" depicts the kind of learning that is taking place in the above-mentioned settings. Falk and Dierking (2002) came up with a new term of free choice learning to explain the learning that occurs in out- of-school settings. According to the authors, it is the learning that takes place when individuals have control over what they want to learn, where and with whomever they want. Current research suggests that museums and science centers may be used as places students use hands-on activities to construct their own understanding of science. Authors such as Anderson et al. (2003), Falk and Dierking (1992, 2000, 2002), Hein (1998), Kisiel (2003), Jung (2004), and Ramey-Gassert et al. (1994) suggest that museums are considered avenues for informal learning, yet little is known about how classroom teachers link the experiences students have at these informal settings to their teaching practices or to topics being studied in school.

Cox-Petersen et al. (2003) suggested schools and families see museums as learning environments meant to supplement learning in schools. The authors also went on to state that students are able to remember more of science content when they take field trips to museums and other informal settings. As recommended by the AAAS (1993, 1994) and the NRC (1996) students need to actively participate in their learning to gain high level of scientific literacy. Nevertheless, Cox- Petersen et al. argue that learning in museums is difficult to measure, though it can provide teachers with additional resources to help enhance their instruction.

The committee on science and technology stated in 1985 that museums in the United States have continued to make contributions that would lead to the advancement of modern science. Museums provide data relevant to environmental changes and are helping to look for solutions to habitat destruction, ecosystem disruption, and other issues that are plaguing our world environmentally (National Committee on Science and Technology, 1985). Museums also lead in the documentation of cultural diversity and address the problems of cultures disappearing.

If our future depends on the preservation of biological diversity, then the research conducted by museums are very important. This line of research in turn strengthens the education of children in elementary, secondary as well as undergraduate and graduate students. The above-mentioned committee also agreed that museums and science centers continue to “play a role in public education” (p. 40).

Investigating Learning in Museums and Other Such Institutions

The National Association for Research in science teaching (NARST) states that, learning is a cumulative experience (Dierking et al., 2003). Children need experiences from various situations to construct scientific knowledge, attitudes, behaviors and understanding. Therefore, learning in a museum-like setting broadens the views of students and gives them real-world experiences in a physical and social context (Dierking et al., 2003). The report by NARST suggests that learning is a cumulative process that involves connections and reinforcement of all the learning experiences already encountered in the classroom. In the teaching of science in elementary schools, a museum-like setting can provide the reinforcement of science concepts learned in the classroom. This in turn provides the motivation, curiosity and interest students need to construct meaningful learning.

For students, their museum experiences take place by teachers taking them for fieldtrips. The aim of these fieldtrips to science museums is usually set to promote positive attitude towards the learning of science (Jung, 2004, citing Ramey-Gassert et al., 1994). Science literacy in elementary schools can be enhanced through visits to museums if it focuses on helping students develop questioning skills and learning how to discuss issues. Different science centers and museums can serve as non-threatening environments, especially for students who do not have the opportunity to visit such places (Ramey-Gassert et al., 1994). Other research also reveals that when students are placed in such non-threatening and non-evaluative situations as compared to their classrooms, girls tend to learn science better (Jung, 2004). Jung also suggested that children visiting informal learning or free-choice settings do not show increased knowledge but rather seemed to enjoy the experience which might increase their interest Andrew et. al., 2003; Falk & Dierking, 1992, 2000, 2002; Hein, 1998; Kisiel, 2003; Jung, 2004; Ramey-Gassert et al., 1994).

Though science centers provide resources that are underutilized by public schools, there are however few studies which show how to use these experiences to increase the scientific knowledge of students through teacher professional development. Studies exist that museums can educate the public, school children and teachers, but little literature exists that show how teachers can collaborate with science centers such as museums and nature centers to promote the teaching of science. Also overlooked are the resources available through science centers and museums of which teachers should be aware. In providing authentic learning Rennie et al. (2003) noted that museums provide a physical setting that is important in the learning of science. Just as visitors to museums have a range of experiences, students going on fieldtrips to museums can have an extraordinary experience if their teachers do a follow-up activity when the students go back to school. Kisiel (2003) stated in his study that often times students go on a fieldtrip because it is part of the curriculum but some teachers fail to take the opportunity to make it a rewarding or an educative learning experience for the students. In order for students' attitudes to improve towards the learning of science, all the experiences relating to the teaching of science must be minds-on as well as hands-on (Hein, 1998). Teachers need to learn what knowledge students gained from the fieldtrip experience.

The word "experience" is very important in this study. In order to understand the significance of the word it is relevant to explore its meaning. In a 1993 article in the *Educational*

Researcher, Eisner described experience as being “the bedrock upon which meaning is constructed and that experience in significant degree depends on our ability to get in touch with the qualitative world we inhabit” (p. 5). In order for students to understand what is being taught they need the opportunity to have different kinds of experiences which in turn lead to constructing different meanings (Eisner, 1993). This is because scientific concepts are formed from the world students experience and with which they interact. Therefore, what is the difference between out of school learning experience and the traditional classroom setting? According to Ramey-Gassert et al. (1994), the potential of science centers include, “nurturing curiosity, improving motivation and attitudes, engaging the audience through participation and social interaction and enrichment. By nurturing curiosity, the desire to learn can be enhanced” (p. 434). Curiosity according to Griffin (1998) leads learners to forge understanding of new experiences based on the current understanding and past encountered experiences. Thus, increasing the opportunity for curiosity is important to change the learner’s attitude that in turn helps them make sense of their environment. As with most subjects, when students are engaged, they seem to be more attentive and interested in what they are learning. Citing Resnick (1987), Ramey-Gassert (1997) noted that learning in the traditional school setting tends to be detached from real world connections or experiences. In out-of-school settings however, children are given the opportunity to interact physically with real elements individually or in a group that allows them to experience learning deeply. Despite these advantages, many teachers rarely incorporate these resources into their curriculum. Informal learning environments also provide students the opportunity to use their multiple intelligences (Gardner, 1991). They offer learners more non-verbal experiences, visual displays instead of the traditional use of more abstract symbols (Ramey-Gassert, 1997).

Museum Professional Development Programs and Teacher Instructional Practice

Review of the literature revealed that museums have become relevant in public education. Gargus (2006) in his study explained that museums over the years have contributed to the education of the general public. In citing Floyd, (2004) Institute of Museum & Library Services (2002) and Kilpatrick (2001), Gargus also suggested that one area in which museums have served the educational community is through fieldtrips. He went on to state that there is compelling research on how the services museums offer have continued to grow. One such service includes museum professional development programs for teachers. Price and Hein (1991) noted, "social efforts to involve a wide range of agencies in education have combined to strengthen the educational role of science institutions" (p. 506).

Through the call for reform, in the teaching of science, the NRC (1996) identified the role of teachers as an important part of the solution. Yet many researchers (Lieberman, 1995; Loucks-Horsley et al., 2003; Richardson, 2003; Speck & Knipe, 2005; Supovitz & Turner, 2000) have noted the inadequacy in programs that are supposed to improve the instructional abilities of teachers. Kosasih (1998) supports this argument by stating that most in-service programs ignore the need of teachers and they seem to be very random and disjointed in nature.

Informal science environments such as museums and science centers are said to provide a wealth of educational resources that teachers need to enhance their science content knowledge and instructional practices (Anderson et al., 2003; Falk & Dierking, 1992, 2000, 2002; Hein, 1998; Kisiel, 2003; Jung, 2004; Ramey-Gassert, 1997; Ramey-Gassert et al., 1994). In the literature it also suggested that museums promote collaboration with diverse groups of teachers and encourage the sharing of their expertise and new insights that can be transferred into their teaching practices (Falk & Dierking, 2000; Dierking, Ellenbogen, & Falk, 2004; Gargus, 2006;

Lieberman, 1995, Penna, 2007). Despite this knowledge of science museum and their professional development programs, there is lack of evidence or research on how effective these programs are in changing teaching practices of elementary school teachers.

What makes informal settings good learning environments? Science centers realize that people come with their own desire, zeal to learn, different interests and learning styles and other experiences that shape what they intend to learn (Ramey-Gassert, 1997). These informal settings therefore provide their visitors with engaging, enjoyable, non-threatening and motivational activities to meet their diverse needs. For students who are used to the structured setting of schools, science museums provide an unstructured, no assessment, voluntary environments which focuses on them. They allow children to play, explore, participate in the learning process and accommodate all learning styles as advocated by constructivist theorists. For learning to occur, the learner must be permitted the opportunity to discover new information and investigate that new information in order to construct their own meaning (Csikszentmihalyi, 1987)

Whereas people view museums as places which house valuable collections, museums have shifted their focus to providing rich environments that allow children to interact, wonder and touch real objects. As observed by Ramey-Gassert (1997), science centers and museums make available a free-choice, self-paced and multi-sensory place for learning to occur. This in turn fosters the learner's curiosity thus laying the foundation for science learning. Science centers allow students to go beyond their prior knowledge, to think scientifically, reflect, observe and make connections to their everyday lives. As constructivist theorists believe, active participation, physically interacting with objects increased the ability of students to retain information (Ramey-Gassert, 1997 citing Madden, 1985). Another point to note is the social component of learning in science centers. Out-of-school environments afford pupils the privilege of interacting with their teachers, peers and parents who act as chaperones on fieldtrips. Fieldtrips leave memories that last a lifetime. They provide a rich range of motivating experiences that help extend science learning in the classroom. Johnson (2005) suggests that science centers do not impose curriculum but rather what is to be learned is determined by the learners themselves. This is because every learner's experience comes from a different point in the pathway of learning. The science center learning process according to Johnson can be simply put as "attraction, engagement and ownership" (p. 3). Although Dierking (1991) viewed "learning as learning" a distinction can be made regarding informal learning. Learning in an informal setting accurately represents people's everyday lives experiences much more than the formal teaching and learning situation (Johnson, 2005). Johnson also emphasized the fact that it is difficult to document how much learning takes place in science centers. This is because the learner might not immediately realize the relevance of what is learned at that particular moment. Learning in science centers is special because unlike the classroom, science centers encourage students to move freely, while interacting with many physical objects. They are also free to make their own decisions about how to construct their own learning. Johnson went on to add that science centers provide what Dierking and Falk (1994) and Falk and Dierking (2002) referred to as "free choice learning environments" (Johnson, 2005, p. 6).

What is known of science center educators? There is very limited literature that discusses the difference between the educational background and employment background of science center educators and traditional educators. It is however important to note that science center educators' offer something different from what is documented in teacher training programs. Science center educators sometimes referred to as naturalists, typically have a wide knowledge of the ecological environments in which they work. In comparing the learning that takes place in museums for example to that in schools, Ramey-Gassert (1994) noted that the use of concrete hands-on learning objects is promoted in cooperative settings. In schools however, use of textbooks, verbal explanations and independent work is promoted. The teaching of science in schools is too often teacher-centered rather than learner–centered.

St. John (1990) recognized the difference between the training and education of museum employees and noted that many of these employees are mostly research scientists who want to share their enthusiasm for the subject matter. Sometimes they can be frustrated scientists who are using informal settings as venues for expressing themselves in their particular fields of interest. Jung (2004) added that out-of-school educators can also be traditionally trained educators who were tired of being confined by the bureaucratic process of schools and thus wanted the freedom to choose whatever their interests. In some informal settings science educators are not generally certified teachers but rather have a specified training in environmental studies, natural sciences, anthropology, paleontology, astronomy or geology and physics, to mention a few. On the other hand traditional classroom teachers may not have the experience of being exposed to the same variety of the field of science. Though not confirmed by research, this may contribute to the differences seen in the teaching of science in the classroom and in informal settings. This is because teachers during their teacher-education program may only have had the opportunity to take only one science course especially if they were not science majors. Jung (2004) in her study cited Bailey (1988) as stating that elementary teachers are unprepared to teach science because of the insufficient background in the field of science. Evidence of this was cited from statistics compiled by the National Science Foundation as proof that “only one in three elementary school teachers had ever taken a college chemistry course and one in five a physics course and half have never taken calculus" (p. 35).

In light of this evidence, it is frequently difficult for teachers to provide engaging science curriculum and are more comfortable using science textbooks that have worksheets and assessment at the end of the chapters or units. Although there has been a national call to improve science teaching especially with the use of hands-on methodology, teachers still stick to the old ways of doing things (Jung, 2004). The out-of-school educators on the other hand have different presentation styles. They present information in a more engaging and interesting way by using objects, artifacts and exhibits related to their area of expertise (Jung, 2004).

The programs provided in science centers are usually presented to groups of all ages, home-schooled children, and to the general public, which gives them a variety of experiences with a wide range of pedagogical content knowledge. Thus, they need to be skilled in the art of presenting their programs through storytelling, in order to help their audience create a vivid picture of the object that is being presented. According to the Encarta World English dictionary, interpretation means "establishment of meaning**:** an explanation or establishment of the meaning or significance of something through art." It is important to note that due to their lack of formal teacher education training, museum or science center educators may lack skills in classroom management or evaluation of what is learned. They also may not have an effective teaching technique as they may not be knowledgeable in child development (Jung, 2004 citing Ramey-Gassert et al., 1994). Semper (1990) stated that though the extent of the learning that takes place in museums cannot be fully understood and they are not schools, they do however have anecdotal evidence showing that learning opportunities are being offered that are difficult to replicate.

Current research (Colburn, 2008) suggests that educators in out-of-school setting use different presentation styles for presenting artifacts to help their audiences convey meaning. Through interviews with teachers, a museum and a science center educator, this research examines how both can collaborate to create an efficient way to teach students science. Since more research exists about how museums can contribute to the scientific knowledge of students, this researcher set out to find out what professional development programs museums and science centers have for teachers to improve their science teaching practice.

Relevance of Research

The literature on museums and science centers focuses on the contribution these centers are making to public education especially in science learning. It also reveals that museums are addressing some of what is lacking in science education. They are providing professional development programs where teachers can work in collaboration with other teachers and can learn to use the vast science teaching resources needed to enhance their knowledge of science (Ramey-Gassert, 1997). The literature on how teachers learn stresses the need for teachers to look for other ways outside their schools to professionally develop themselves in order to gain new knowledge in their subject area (Penna, 2007). There is however, lack of research on the effectiveness of these museum programs on teachers and their ability to change their instructional practice. Educational reformers see teachers as an important piece of the puzzle of helping students gain a variety of learning opportunities, yet there is little research into teachers' perceptions of what they are learning from these professional development programs (Lieberman, 1995). The literature reveals a growing body of research on the power of professional development in the way teachers learn and teach, yet there is lack of evidence of how these programs are connected to their classroom life or professional development needs

(Lieberman, 1995; Loucks-Horsley et al., 2003; Richardson, 2003; Speck & Knipe, 2005; Supovitz & Turner, 2000).

Conclusion

An examination of the literature related to museum and science center professional development programs with specific emphasis on improving the attitude and teacher self-efficacy towards science and science teaching has been provided in this literature review. A number of qualitative and quantitative studies have been conducted to reinforce the ability of teachers to teach elementary school science. Recent studies have focused on visitor and student fieldtrips to museums. There is however little done to investigate museum and science center professional development programs and their effect on science teachers' instructional practice. Further studies of the literature have confirmed that there are major concerns about science education and the attitudes of teachers towards the teaching of science. There have been studies indicating that the teaching of science can be changed by encouraging science teaching methodology for pre-service teachers. However, there is not much in terms of professional development in the area of science for in-service teachers. As a result of the *No Child Left Behind* act, emphasis is only placed on reading and mathematics.

The limited number of publications found shows collaboration between schools and museums is increasing. Research exists on how these collaborations work but how effective these collaborations are in affecting the way science is taught is inadequate. It has been identified historically that research on teachers' knowledge and effectiveness has been provided through correlational data on quantitative measures of teacher's knowledge. What is lacking is necessary information to deal with concerns on the importance of one's subject matter knowledge. Recent researchers are beginning to recognize the need for more qualitative measures of what teachers know and how it affects their instruction. This research study investigates science curriculum in relation to how teachers use science centers to provide adequate inquiry based on scientific knowledge to their students. A major rationale of this research is to fill the gap that currently exists in the literature on the effectiveness of collaborative programs. It contributes to finding the relationship between museum professional development and science teachers’ change in teaching practice, which in turn contributes to the discussion of how to improve science education in America.

CHAPTER 3

Methodology

Introduction

As documented in Chapter 2, many teachers do not have the self-confidence, self-efficacy and motivation to effectively teach elementary science. A major concern of this research is that little is known about how science museum professional development programs can effect change in elementary teachers' ability to improve their teaching of science. It is in recognition of this gap in the literature that this study's ultimate goal is to gain more insight into science museum professional development programs and their ability to improve the self-efficacy and confidence level of science teachers in elementary schools. This study addressed the following research question: How do the professional development programs at museums and science centers help teachers improve their instructional practice with regard to teaching inquiry-based science instruction?

A qualitative collective case study was used to investigate the effect of museum professional development programs on the classroom experiences of five science teachers. This kind of design allowed for a detailed natural examination of the research question. A case study method also allowed for the kind of investigation Creswell (1998) called "detailed, in-depth data collection involving multiple sources of information rich in context" (p. 61). A case study approach was necessary to explore the complex phenomena where boundaries within contexts are not obvious and multiple data sources are required for triangulation and are entrenched in the real world (Gillham, 2000; Yin, 2003). The study examines how museum professional development programs attended by teachers helped improve their instructional practice with regard to teaching inquiry-based science instruction. Museum science education and professional development for classroom teachers is a new phenomenon, which has not been fully researched. This is especially true in the case of how teachers who attend these programs feel about them. Literature shows that research has only focused on how museums educate the general public through fieldtrips, and family museum visits (Falk, 2001; Falk & Dierking, 2000, 2002; Hein, 2002; Kisiel, 2003). By focusing on the perspectives of science teachers attending the professional development programs, this research adds to the body of research that addresses this issue.

Participants

The study chose three teachers who were attending a Midwestern city museum professional development program, another three attending another Midwestern city science center and two workshop instructors from the two organizations. To examine how museum programs affect the field of science education, teachers were selected based on their interest in participating in the program and their ability to help this researcher best understand the phenomenon (Creswell, 2005). To keep the study balanced, teachers were purposely selected to represent different grade levels (1-6) and levels of teaching experience. These grades were selected because at these elementary levels teachers were teaching in a self-contained classroom, which made classroom observation more comprehensive. It also allowed the researcher to gain different perspectives about participants' teaching practices (Creswell, 2005). To guarantee rich data collection, the researcher selected participants from several school districts in some Midwestern cities to allow for different instructional practices and experiences. Related literature reveals that a small sample size of 8 is common in qualitative case studies (Creswell, 2005; Miles & Huberman, 1994). This small sample size allowed the researcher to give a detailed description of each case. The small sample size was also due to the dissertation time constraint, and school district's academic calendar year (Penna, 2007). The ultimate goal of this study was to use self–reporting techniques to gather information on how teachers feel about their ability to teach science and how the professional development helped them to make instructional changes. It was also to further the research knowledge of science museum and science centers' professional development for teachers and in turn enhance science teaching.

Research Design

In this study a collective case study was employed. A collective case study according to the literature is an instrumental study consisting of multiple cases focusing on a specific issue to understand each case (Creswell, 2005; Stake, 1995, 2003). The goal was to examine how science teachers' participation in a museum professional development program changed their instructional practices. The importance of selecting each case was based on what Stake (2003) described as "balanced, variety and the opportunity to learn" (p. 135). There were other reasons for selecting a qualitative research design. Data collection occurred in a natural setting, where participants' perspectives were interpreted directly (Bogden & Biklen, 2003; Miles & Huberman, 1994; Stake, 1995). A case study according to Yin (1994) "is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13). Since qualitative research is more concerned with daily processes that shape a phenomenon (Bogden & Biklen, 1998; Gillham, 2000) a case study design allowed the researcher to view from the teachers' perspectives how what they do daily shapes their instruction. Also since several cases were examined to provide insight into the knowledge base in literature of how museum programs can change the way teachers teach science, a collective case study was more appropriate (Stake, 2000). To triangulate data, ethnographic tools such as observation and interviews were used in conjunction with a teacher efficacy survey to provide a holistic picture of participants' self–reflection and their teaching practices in the area of science. Consent and agreement to complete the study were obtained from each teacher and museum professional development staff.

Again, as this research focused on classroom practices, there was the need to reveal their self-efficacy beliefs to science teaching. A self-reporting of these beliefs informed the research of how these beliefs influence the way the participants teach science. The science teaching (STEBI-A) self-efficacy instrument developed in 1988 (Riggs) was adapted by Ramey-Gassert (1993). All 20 goals are presented and ranked according to a five point rating scale (5=Strongly Agree, 4=Agree, 3=Uncertain, 2=Disagree, 1=Strongly Disagree).

The Position and Credibility of the Researcher

As in any qualitative investigation, the biases of the researcher have the potential of playing an integral part in the study and perceptions that accompany and influence data collection and analysis. In light of this, the researcher recognized her biases and managed these preconceptions by reporting what the participants' told her and did not interject my views thereby allowing the participants' voices to be heard. Since the researcher collected data on a topic so dear to her, she had to reflect on her role as a researcher. In dealing with the issue of validity and reliability as part of the data collection and analysis, it was important to consider what Flowers (2007) had to adhere to in her research of three African American professors. She stated that it is of utmost importance to establish a credible representation of information gathered. In following her recommendation, I felt I needed to address the issue of being a teacher and how this might interfere with my objectivity. I had to be cognizant of my role as a non-participant observer. Just like Flowers, I also recognized the "different micro-culture that [I] represented" (p. 45). I am an elementary school teacher, student of curriculum and instruction and a teacher who is passionate about science teaching. It is of significance to this study to note that these micro-cultures represented probably affected the design of my questions and the way I interviewed teachers. I hope my unique situation served as an advantage in providing a scholarly representation of the perception of teachers involved in this study. Thus, the fact that I was considered as a non-participant observer, I would like to acknowledge my personal and professional biases to this research that might have hindered my interpretations.

First there was the bias of observation. Before going into participants' classrooms to observe science teaching, I had to reconcile my personal assumptions about classroom expectation and relations. I tried to stick to writing factual objective notes as stated by Hendrix (1986 as cited in Flowers, 2007). Despite her own assumptions, Hendrix, according to Flowers, understood that there are many aspects of an observation setting that are ignored as the phenomenon is being explored. Though I have experience in the classroom, I understood that during classroom observation, I had to "strive to keep an open mind" (Gillham, 2000, p.13) in order gain the new experience. The reason as Gillham noted was that being a teacher, it was easier to assume that "gives me privileged understanding of others in similar context" (p. 18). Gillham goes on to state that the researcher had to realize that each school has its own culture and a conventional way of doing things. It was also important to note that, in participating in the museum and science center workshops, it was natural for me to think substantively about how I would have implemented some of what I learned at these workshops in my own classroom. My perceptions might have influenced how I heard and interpreted views from the teacher participants of how they were going to implement some of the workshop information in their classrooms. My goal was to ensure that this did not tint my interpretation of teacher perceptions. The goal was not to overlook any information but to collect as much information as I could and to remember that as in any case study research, it is wise not to disregard any information. It was also important to corroborate any information with teachers involved in the study in order to better represent their views. The ultimate goal was to report what I saw in terms of science teaching and not interject my experience. It was also important to note that one limitation to in this study was the fact that change takes time and this research had a 3-4 month time constraint.

Data Collection & Analysis

The data collection phase of this study adopted a method that is common in qualitative case studies which includes semi-structured audio taped interviews, observation, self-efficacy surveys, themes and interpretation. Table 1 shows the data collection plan. The data collection phase of this project took a period of three months. The first data collection was a pre-observation interview of teachers that included the self-efficacy survey (STEBI-A) that was given to teachers to determine their attitude towards science teaching.

Self-efficacy scale. Within the 12 weeks of data collection, there were two classroom observations, a workshop observation and two interview sessions with teachers and museum and science center staffs. After the workshop observation, a 20-question teacher-efficacy survey (See Appendix B) was administered to teachers. This instrument was designed to measure science teaching efficacy beliefs of in-service teachers. It was first developed by Riggs (1988) to help researchers analyze efficacy beliefs of elementary teachers with regard to science teaching. Based on Bandura's (1977, cited in Ramey-Gassert, 1993) construct, the STEBI-A that had 20 items in a Likert-type scale format, was later used by Ramey-Gassert (1993) and Jung (2004) in their examination of science efficacy beliefs of in-service teachers. This focused on the teachers and their attitude towards the teaching of science. The survey results served as a tool for highlighting their beliefs as they shape their teaching. As part of the data collection there were other formal observations that took place in their classrooms and interviews that were conducted at a venue of the teachers' choice.

Observations. The observation process chronicled a detailed description of the way the teachers taught science before and after participating in the museum and science center workshops (Bogden & Biklen, 2003, Creswell, 2005, Penna, 2007). The observations helped focus the research on the issues of the study. They also enabled the researcher to draw inferences about participants' perspectives on science teaching and how museum and science center professional development programs affect the way they teach. Observation according to Creswell "is a process of gathering open-ended, firsthand information" (p. 211). Observation as a research tool is considered a primary source or the most direct way of data collection that is well accepted in qualitative research (Creswell, 2005; Gillham, 2000; Merriam, 1988).

Observation as a data collecting technique allowed me to experience science teaching first hand and notice things that have become routine for the participants. It also permitted me to write descriptive notes and to record behavior as it was occurring. It probably revealed issues that participants might not have felt free to talk about (Creswell, 1998, 2005; Merriam, 1988; Penna, 2007 citing Angrosino & Mays de Perez, 2003). The observation protocol was in three steps due to the time constraint of this study. The first observation was held in the classrooms. This was intended to observe teachers teaching science before they attended the museum or science center workshops that were held between February and March, 2009. This was later followed by another observation at the museum and science centers. This concentrated on observing the actions, involvement and interactions of the teachers with the museum and science center instructors. The museum and science center observation protocol was divided into four sections; workshop itinerary, museum instructors' lessons, teacher actions and the researcher's reflections (Penna, 2007). With regard to the researcher's role as a participant observer, I tried to remain an observer doing some interactions with participants as suggested by Glesne (1999). Participant observation was necessary to get a richer picture of what was going on in a science classroom and the teachers' instructional practice. The third observation was classroom observation to record any changes in the way the teachers taught science.

Interviews. As preliminary background, a 30-60 minutes audio taped interview was conducted with each participant. This focused on basic information about their educational experience and their science teaching experience and why they decided to participate in the museum program. There was also an interview with museum and science center workshop instructors to get detailed information about the relevance of their programs and their contribution to the teaching of science. A final interview was then conducted to allow participants to reflect on the change in practice and self-efficacy if any. According to Gillham (2000), Stake (1995) and Yin (2003) interviews are an important source of data collection for multiple realities in case studies. To gain the unique perspectives of the teachers, the interview format of this study was open-ended (Stake, 1995, 2006). The most common form of interviews according to Merriam (1988) is the "person to person encounter" (p. 71). She went on to state that the interview should have a purpose, which is to find out information that might not be observable. These sets of observations and interviews allowed the researcher to collect data that included participants' general information and a self-reporting reflection towards science teaching and if participating in the museum program improved their teaching practice. All interviews were audio taped and transcribed. The protocols for interviews can be found in Appendix A and C. These observations and interviews as stated by Penna (2007) provided rich data that “reveal complexity within a real context (Penna, 2007, p. 68 citing Miles & Huberman, 1994, p. 16).

Table 1

Data Collection Plan

Phases	Months	Science Teaching Self-Efficacy survey	Interviews	Observations
1	February	Distribution and Collection from teachers	Educational background and teaching experiences	Museum workshop observation
2	February-March	Discuss results of survey with teachers	Collect details of changes in teaching	Classroom observation
3	April-June	Begin Analysis	Collection Reflection of experience	Interpretation of observations

Summary

In order to investigate the role of museums in science education, a qualitative design was necessary for this case study research. It was also needed to understand what teachers who were participants in these museums and science center programs think about the programs and whether these programs have any impact on the way science is taught in their classrooms. As stated earlier in this chapter, data was collected and triangulated through classroom observations, interviews and a self-efficacy survey. Results were analyzed to reveal emerging themes. The use of this data collection plan helped strengthen the validity of this study. Using a variety of strategies also helped in the triangulation of data and assisted in answering the research question: How do the professional development programs at museums and science centers help teachers improve their instructional practice with regard to teaching inquiry-based science instruction?

CHAPTER 4

Findings

Introduction

The goal of this research was to better understand the role museum and science center teacher professional development programs play in the science education of elementary school students. Participants, who included the museum and science staff and teachers who attended the workshops, were questioned on their views about the programs and its effectiveness in the teaching of science in the classroom. Participants were further asked to comment on the workshops they attended, what they learned, and how they implemented what was learned in their respective classrooms. Teachers were also asked if their workshop experience benefited their students in any way. Additionally, classroom observations were conducted to provide detailed information on how teachers use what they learned from these professional development programs in their classrooms. Overall findings follow a brief description of the centers used in this study. Rather than focus separately on each of the in-depth studies, emerging themes and subthemes from the qualitative approach are presented describing how teachers view the professional development programs at the museum and science centers as a catalyst for improving their science instruction. The purpose was to show how professional development activities contributed to teachers' instructional practice. In addition, a brief introduction to the six teachers and two instructors participating in this study is presented in order for the reader to be acquainted with each teacher.

Overview

To further understand the role of the two centers and the participating teachers, a brief history of their professional responsibilities, background information and positions is discussed following a description of the centers. To protect the identity and confidentiality of the participants, pseudonyms have been used. A summary of the participants is presented in Table 2.

Challenger Learning Center. Challenger Learning Centers were established around the United States in honor of the seven space shuttle astronauts who died on Jan. 28, 1986. The Challenger Learning Center located in this Midwestern city was the 16th one to open. The goal of the center is to continue the mission of the astronauts who perished aboard the space shuttle Columbia. According to the writer of the 10th anniversary issue of *Museography*, the official magazine of the museum, the goal is to continue the crew's mission "by delivering applied math and science knowledge as participants take part in mock space adventures" (Thinnes, 2003, p. 3). Since its inception in 1993, the center has held workshops for teachers to take simulated missions or voyages to Mars, Rendezvous with a Comet, Encounter Earth and Return to the Moon. The center prides itself on its ability to promote scientific literacy that encourages inquiry, exploration, problem solving, and increase students' interest in science, mathematics and technology. Most importantly, the center states that its programs are tailored to reflect the recommendations of the National Science Education Standards as stated by the NRC (Challenger Center for Space Science Education, 2001).

As stated in their mission preparation, the challenger learning experience includes a pre-visit activity, the mission, and the post-visit activities. Before students come for the missions, teachers are required to attend an in-service training for the voyage they intend to bring their students to experience. As part of the one-day workshop for teachers, they are offered educational materials to be used in the classrooms and they also fly their own simulated missions. During the workshop, they also learn how to incorporate the information and how to prepare their students for a mission (Challenger Center for Space Science Education, 2001).

Commander Kathy. Commander Kathy is the flight director of the challenger center at the community museum and has been working there for the past nine years. She holds a Bachelor's degree in Biology, a K-8 and 9-12 certification in Biology and Physics. Commander Kathy thinks her educational background serves her well in knowing how to work with teachers and students who participate in the various missions that the Challenger Learning center holds. Her responsibilities include maintaining the Challenger Learning Center missions, trouble shooting when there are glitches and making sure that when teachers bring their students, everything runs smoothly.

Ms. Harriet. Ms. Harriet is 4/5 split teacher at a local Catholic private school, who has been teaching for the past 14 years. Ms. Harriet teaches all subjects and this is her school's first time working with the museum. Ms. Harriet holds a Bachelors of Arts degree and a minor in mathematics and science with an elementary certification. She notes that her background in science is serving her well in providing her students the necessary skills needed to fulfill the Michigan Grade Level Content Expectation (GLCES).

Ms. Bessie. Ms. Bessie is a veteran teacher who has been teaching for the past 36 years in the same school district. She is the department chair in her building as well as at the district level. Ms. Bessie holds a Bachelor's degree in science with a major in Biology and minor in Chemistry and also holds a Masters degree in Education. Ms. Bessie has been involved in many professional development programs in her district. She has trained other teachers in implementing their new science curriculum, participated in a Data Stream Course in

Oceanography in one of the Midwestern universities and also has been part of the National Science Foundation project known as Project Wet. Thirteen out of her 36 years of teaching have been devoted to teaching science at both the elementary and middle school level. Ms. Bessie has been working with and taking students to the museum for 10 years.

Ms. Marie. Ms. Marie has been teaching 12 years in a school district located in a Midwestern city. She is in a self-contained classroom where she is responsible for teaching science. Ms. Marie majored in Geology and Earth Science as part of her Bachelor's degree program. She also received a Masters degree in Career and Technical Education. She attributes her success in teaching science to her educational background and all the professional development programs she has attended throughout her 12 years of teaching. She also mentioned taking a significant amount of extra hours of science courses and participating in a data streaming program as her colleague Ms. Bessie. Ms. Marie values professional development that is relevant to her curriculum and building's goals for their students.

Ms. Ann. Ms. Ann, as with the other teacher, who have been taking students to the museum, holds a Bachelors degree in Biology and another Bachelor's degree in Science Education. She also holds a Masters in Elementary Education. Ms. Ann is a veteran teacher who has been teaching for 19 years. Out of the 19 years she has been taking students to the museum for the past 13 years. She asserts that her experience in science is of benefit to her students. She also served as a board member at the museum for several years.

Table 2

Background of Teachers Involved in Study

Name	Years of Teaching	PD	Grade Level	Degree
Ms. Harriet	14 years	Museum workshop	4th and 5th grade	Bachelor's in Arts with minor in Mathematic and Science
Ms. Bessie	36 years	Museum workshop	6th grade	Bachelor's in Science with a minor in Chemistry
Ms. Ann	19 years	Museum workshop	6th grade	Bachelor's in Biology, Master's in Elementary Education
Mr. Frank	8 years	Science Center workshop	2nd grade	Bachelor's in Science
Ms. Savannah	7 years	Science Center workshop	4th grade	Bachelor's in Elementary Education with minors in Science and Spanish
Ms. Amy	1 year	Science Center workshop	2nd grade	Bachelor's in Elementary Education
Ms. Noelle	9 years at the Science Center	Instructor science center	N/A	Bachelor's in Elementary Education and a Master's in Elementary Education
Commander Kathy	1 year teaching 9 Years at the Museum	Instructor Museum	N/A	Bachelor's in Biology and Physical Education

The Area Mathematics and Science Center. As has been stated in earlier chapters of this research, the 1980s were when there was a full-scale call for reform in science education. This was also the case in the state of Michigan. There was a general consensus that science was not being "taught well or consistently across the state...it had become a subject that was taught when there was time" (Michigan Math and Science Center Network 2005-2006 Annual report, p. 3). What further raised the commitment to the goal of achieving scientific literacy for all students in Michigan was the release of the project synthesis in 1981 by the National Science Teachers Association research project. Focusing on the personal, societal needs and awareness of science and technology recommended by the project, Michigan Science Teachers Association (MSTA) convened in 1981 in collaboration with the Michigan Department of Education (MDE) to study the state of science education in Michigan.

After meeting for several years, the committee came up with a plan to improve science education and the advancement of technology in Michigan schools. The goal was to help all students understand science as a "living and vibrant view of looking at the world" (MDE, 1991, p. 3) and design programs to assist teachers to achieve this objective. This started new directions for science education based on a project 2061. The goals and objectives became the Michigan Essential Goals and Objectives for science Education K-12 (MEGOSE) (MDE, 1991).

Based on this recommendation the Mathematics and Science Centers were established with grants in cooperation with school districts, higher educational institutions, and science museums by legislation in 1988 (MDE, 1992). According to the 2005-2006 annual report by Michigan Mathematics and Science Center Network (Science and Mathematics Program Improvement, 2005) the centers:

> Serve as catalysts and resources for improvement in the teaching and learning of mathematics and science. They provide services within their regions that enhance and extend beyond those available to local districts. A major focus of their work is supporting schools in meeting the strategic goals of the state board of education which is the priority of the Michigan Department of Education, providing professional development opportunities that enable and sustain effective teaching of mathematics and science by keeping teaching current and the goals of the *No Child Left Behind* (NCLB) which is preparing high quality teachers. (p. 4)

Established in 1991, this local Area Mathematics and Science Center is therefore one of the 33 regional centers in Michigan created to elevate mathematics and science education for all students in Michigan. They started with just the physical science kit and life science was later added. At the time of its inception it only served the local school district. When the curriculum was first written in 1991, it centered on MEGOSE, which was the first real organized benchmark curriculum, based on the requirements of the National Science Standards. This later became the Michigan Curriculum Framework (MCF) and the Michigan Content Expectation (MCE) (interview with Ms. Noelle, April 21, 2009). The program has continued to change depending on the needs of the state. The goal of the center is to make sure that elementary school teachers have materials and a science curriculum that aligns with the state's goals and expectations. The center's most important objective is that students will be exposed to inquiry-based lessons that will give children the opportunity to observe, collect data, and write reports based on their own experience (Science Center Brochure, obtained February 25, 2009). According to the outreach teacher in the center, the new units that have been added "will give students the opportunity to make connections to other content areas such as mathematics and language arts content expectations" (Interview with Ms. Noelle). Another responsibility of the center is to provide lessons to high school students from all over the county who excel in mathematics and science.

Ms. Noelle. Ms. Noelle has been the outreach teacher at the center for the past nine years and she holds a Bachelors degree in Education with a triple minor in Social studies, English and Elementary Education and a Masters degree in Elementary Education. When she was hired, her job was to model how to teach the science units to teachers in their classrooms. She stated that she would go in and model to teachers the inquiry aspect of it and the assessment piece. After building relationships with the teachers they invited her to observe them to see if they were asking inquiry style questions. She asserts that her background as a former teacher helped her succeed in this position (interview with Ms. Noelle, April 21, 2009). As at the time of the interview, she said, now she does anything that needs to be done at the center. She assists teachers with science units, does professional development; does science units training of K-7 administrators and workshops for science leaders. She occasionally still goes to classrooms to model to teachers how to teach the units, do the activities in a more student directed way and teach teachers how to manage their time and materials.

Ms. Amy. Ms. Amy is one of the teachers who participated in the science center professional development workshops. She is a first year teacher at a Catholic elementary school (A) in a Midwestern city where she teaches second grade. Ms. Amy holds a Bachelors degree in Science from a Midwestern university with a mathematics and science minor. As is required of all the teachers at her school, Ms. Amy was required to attend this workshop because her school was starting a new science program with the science center. A professional development activity is required when the teachers are starting a new program.

Mr. Frank. Mr. Frank also teaches in a Catholic elementary school (A) as Ms. Amy and is the other second grade teacher at the school. He has been teaching in this Catholic school for the past eight years. Mr. Frank holds a Bachelors degree in Science and holds an elementary teaching certificate. He is currently pursuing a graduate degree in Science Education and he states that his science background is a significant asset to him as he is able to respond to students' questions. His success in the classroom can also be attributed to his previous work experience in the private sector in a science related field.

Ms. Savannah. Ms. Savannah is a seventh year fourth grade teacher in a general education classroom in a public school in a Midwestern city. She holds a Bachelors degree in Elementary Education with a minor in science and Spanish. In addition, she has a Masters degree in Educational Leadership. Her experience in Spanish serves her well in interacting with students in her class who are Spanish speaking and have parents who are not English speakers. Throughout her seven years in the teaching profession, she has attended many professional development activities or workshops. She sees the science center workshop as a step in the right direction in enhancing professional growth of teachers.

Observations

Museum Observations. A total of 15 in-service teachers were observed during the course of two workshops attended by the researcher (only three agreed to participate in this study). An observation at the museum consisted of observing teachers learn about the Challenger Center and what their students will be required to do during their fieldtrip to the museum. Each lasted from 8 a.m to 3 p.m, and participants were interviewed by the researcher during their lunch break. For the first half of the workshop, teachers were welcomed by museum staff and introductions were made as the teachers were given refreshments and a folder filled with information needed for the day. Teachers were then given a brief tour of the museum. This tour included a planetarium demonstration by the museum staff. During the tour, teachers were given the history of the exhibits. At the completion of the tours teachers convened again at the presentation area to receive an introduction to the activity their students will be participating in when they came for their fieldtrip. The visit is for the Voyage to Mars. After the debriefing, teachers were allowed to go to lunch on their own. This gave the researcher the opportunity to interact with participating teachers. When asked if the information they received was beneficial in helping them prepare their students, they all responded that the information was very valuable and that it would have been impossible to prepare their students without coming to this workshop. A participating teacher, who is referred to as Ms. Harriet in the study, added that

> she likes the way they went through the background information about the place, it will make it easy for me to explain it to the kids. And also when I go back to school to look at the resources they gave us I will be able to decide what is relevant to my students.

The second training session started at 1 p.m. with flight commander Kathy giving the mission guidelines and explaining what the teachers were going to do at the simulation activity. Commander Kathy told the teachers that they would be put into teams that work together at the different stations. She announced that the stations included the navigation team; isolation team; communications team; medical team; life support; probe; and task control teams. She went on to state the responsibilities of each team and how each team will have to work well together to ensure the success of the mission and the safety of everyone. After everyone was assigned to their teams, they were told to fill out the evaluation forms in the folder they were given in the morning. It was then time for the teacher activity which entailed the teachers going to the space station where they replicated the experience of working in orbit. The experience involved using practical technology applications of mathematics and science, the missions resembles a real space mission.

Science Center observations. A total of 36 in-service teachers were observed during three different workshops organized by the center. Each workshop lasted between three to four hours. Each session was attended by 13 second grade teachers, 12 first grade teachers and eleven first grade teachers who attended an afternoon session. The first 12 teachers attended a morning session and the other 11 who were observed the same day attended the afternoon session. The last 13 teachers attended on a different day. The first two were counted as two different sessions because they were for two different units. At the beginning of each of the workshop sessions, teachers were given a walk through the unit teacher's guide that included background information, student activities; pre- and post- test and a literacy connection of the unit. They were also given a copy of the student journal. The journal has activities that students are expected to complete by the end of the unit. Looking through the binder, the researcher noticed the unit is aligned to Michigan Grade Level content expectations. Also contained in the binder is what students are expected to know and be able to do.

The learning goals are also included in the teachers' manual. The manual is very much scripted to make it easy for teachers especially new teachers to use. In talking to the teachers, the researcher found out that the workshop was very rewarding and informative. A teacher commented that "Attending the workshop definitely makes it easy. I think it is helpful to have somebody else walk you through the binder and to have you practice doing the activities. It gets you excited about teaching the unit." Another stated that "I really like this unit because it allows kids to carry out observations." In all most of the teachers at the workshops felt it was beneficial to them.

Classroom observations. A total of six teachers were observed over the course of three to four months. Three of the teachers were from the museum workshop participants and the other three from the science center workshops. Only six were observed because they were the only ones who agreed to participate in this study. The classroom observations are not discussed in details because the researcher does not want to state the responses of the students as they were not part of the study. Of the six teachers who were observed, the majority of them provided opportunities for their students to predict, explore, observe, plan and conduct investigations while doing hands-on activities. This was especially visible in the observation of Mr. Frank and Ms. Amy's classrooms as they were conducting experiments on plants. The same was true for Ms. Savannah's fourth grade classroom as students were taking apart flashlights to find out the different components. As Mr. Frank and Ms. Amy were co-second grade teachers in the same school, the researcher observed collaboration between the two teachers as they consulted with each other about how to teach the unit.

Findings

This chapter summarizes both the qualitative and quantitative findings of this research. The findings include teachers responses based on the research question that guides a current research and statistical analysis of the teacher efficacy belief survey. The question is: How do the professional development programs at museums and science centers help teachers improve their instructional practice with regard to teaching inquiry-based science instruction? At the end of the interview and observation of the above-mentioned participants, it became apparent to the researcher that two distinct themes emerged in terms of how the teachers feel about professional development workshops they attended at the museum and the science center. The first theme had to do with the fact that some teachers think the workshop helped them improve their science instruction. Their opinion was that going to the workshops definitely helped them teach inquiry-based science. The other major theme shows the opinion of teachers who did not think that going to the workshop made any difference in their science instruction. Their view was that they already knew the content, no new knowledge was gained and some did not appreciate being away from their students.

Despite their opinions, it is important to note that 12 weeks was perhaps not enough time to see noticeable changes or improvements in teachers' instructional practice. Also, it is hard to say if what was observed in their classrooms was as a result of the professional development workshop that the teachers attended. Although a majority of the teachers interviewed saw the professional development program at the museum and science center as beneficial to their instructional practice, the researcher came to the conclusion that more time was needed to notice any actual improvements in the instructional practices of the teachers after attending the museum or science center workshop. Teachers expressed their views about what was valuable about the workshop and what was not valuable. From the interview with participants, there were some major emerging sub-themes that illustrated what each teacher experienced as a result of the workshop they attended. Sub-themes are identified based on responses from both groups.

Summary of Qualitative Findings

Theme one - workshop was beneficial. Some teachers viewed the professional development workshop experience as providing the opportunity to learn new scientific knowledge, experience the new science unit, increasing teacher confidence, interacting with other teachers and increasing their teaching repertoire.

Scientific knowledge. Roughly 50% of the teachers from the museum and the science center valued the professional development experiences they had because it contributed to their scientific knowledge. Most of them noted that they acquired some knowledge about the science unit they were going to teach. It was however noted during the interview sessions that those who reported gaining some scientific knowledge actually reported refreshing what they had done in classes about the content being taught. Examples of such response included Ms. Amy noting “I learned only a small amount of content, mostly to do with plant growth. I had forgotten a lot since I originally learned it, otherwise, most of the content I knew well.” In support, Mr. Frank went on to state that the workshop “refreshed my mind about plants. Being a science major made it easy for me to understand what my students need to know about plants such as how to indentify different plants and what they need to grow.” In the same vein Ms. Savannah added that, “the workshop was extremely helpful to me as a teacher because I learned new content or rather refreshed my brain on science content that I learned in my college courses or previous high school learning.” The responses led the researcher to conclude that they saw scientific knowledge as added to their existing knowledge and not new facts about the subject matter. In their investigation of the impact of museum-created professional development, Melber and Cox-Petersen (2005) stated that the programs “enrich their scientific content knowledge” (p. 103) of the 54 elementary teachers involved in their study. What the teachers involved in this study were referring to was the information in the teacher binder they were given. They saw it as teacher resource allowing for a quick and easy review of the content that was covered. This also gave the teacher adequate knowledge prior to teaching each lesson. For the teachers who attended the science center workshop the "misconception" section was seen as being helpful because it prepared teachers for what they may not expect and allows for a better explanation due to previous exposure or thinking about the possibilities that may come up throughout the lesson or unit.

Scientific methods. In the interview sessions, teachers were asked how the museum or science center experience contributed to their scientific method knowledge. The majority of the teachers interviewed made reference to teaching practices that made a difference to the way their students are now able to experience science that is more engaging. This was attributed to the knowledge gained from the workshops. Ms. Ann's response was that

> The museum teaches how to integrate science with math; it teaches chemistry; and volume and what rocks are made of. The workshop teaches inquiry-based science. The museum staff did hands-on activities; taught them to observe; and to manipulate materials just like the astronauts do.

Ms. Savannah compared her experience with the knowledge gained as a college student by stating that "most of my college professors were scientists and not teachers and so we were not taught how to really teach. I have learned so much in the workshop because I would not have been able to teach science to the children." During his interview Mr. Frank noted that

> It helped me recognize the inquiry aspect of the unit, how to have students investigate, observe and create hypothesis and work to arrive at their own solutions. That is giving students the opportunity to find solutions to problems on their own and building on their background knowledge about plants.

During the observation of both the museum and science center workshops, the researcher did observe that most of the teacher activities included various ideas for inquiry based learning opportunities through a hands-on and minds-on approach. The lessons are designed to get students engaged in their learning. In the group interview with teachers at the workshops the teachers agreed that allowed for better understanding of the content. Ms. Amy added, "I learned that in teaching the unit you have to allow students to observe, do hands-on activities and propose hypothesis. I think all these get the kids involved in the lesson." Field notes indicate that most of the teachers, who attended the science center workshops, set up their classroom science experiments to include hands-on activities. Materials for the experiments included the plants, different kinds of liquids to water plants with and measuring instruments to measure plant growth and had students out of their seats to manipulate materials in both Ms. Amy and Mr. Frank's classrooms. In Ms. Savannah's class, students were divided into groups to take apart flashlights and examine what they were made of and the opportunity to make a homemade flashlight with batteries and bulbs. My observation of these classrooms also established that effective questioning techniques were being used. With regard to the responses provided by the teachers who felt the workshops influenced their instructional practice, the workshops provided activities that were relevant to how they taught science to their students. Thus, the science center professional development program was the one more focused on skills and teaching methods teachers are supposed to utilize.

Instructional methods based on scientific knowledge. During the interview sessions with teachers, they were asked about what instructional methods knowledge they took away from the museum and science center workshop. All the teachers who attended the science center workshop had more to say about being given the opportunity to develop common understanding for new instructional methods that increased their capacity to grow as science teachers. Methods that included organizational learning and routines that they thought were relevant to enhancing their teaching skills. The teachers who attended the museum workshop only stated how it could improve their students' ability to perform the tasks assigned to them during their fieldtrip to the museum. Ms. Amy a first year teacher stated,

> I learned how to organize and present the information and it actually helped me organize my thoughts, manage the students as they carry out the activities and making sure to use the right vocabulary so students can be used to using the scientific terms. In other words, instructional methods I learned included how to set up experiments to create interest in a topic, and how to help retain what students learn.

Mr. Frank indicated in his interview that, “We learned how to manage the activities, how to ask higher order questions and get students interested in the experiments. It is also useful to make materials accessible to all students.” On the instructional method, Ms. Ann a teacher who participated in the museum workshop had this to say,

> The mission activity engages all students. My students were actively engaged the whole time, even students who are academically behind in class. They also learn how to work cooperatively with their teammates. They also make sure that all the materials are accessible to all students and all assignments are completed because they learn that if you don’t do your part, the whole mission could be in jeopardy.

The perception of the science center teachers is that of a professional development program that focuses on helping teachers use their science kits or what Garet, Porter, Desimone, Birman and Yoon (2001) referred to as “helping teachers use particular curriculum materials or prescribed teaching strategies” (p. 923). In addressing this study’s research question, which again is: How do the professional development programs at museums and science centers help teachers improve their instructional practice with regard to teaching inquiry-based science instruction? Mr. Frank responded by saying that,

> I think the workshop helped with my understanding of the scientific procedure needed to teach science in the second grade. The class clearly laid out a step-by-step procedure of

how every unit was to be taught along with the desired results that are expected of every child. The class instructors were very helpful in giving simple ideas that may be used to make sure that every student comprehended what was being presented. The workshop instructors always made sure that the instructional methods were presented at an appropriate grade level with key words and definitions introduced that were easily understandable. I was amazed at how quickly my students grasped the content that was taught and how excited they were every day when we started science. I think children at an early age learn much more quickly when they are allowed to learn with hands on approach. Even my shy and quiet students became actively involved when they were allowed to work within groups. Teaching science at our school has now become much more hands on activity type learning rather than a fact and lecture instruction. Kids now are learning by observing and participating rather than just by listening and reading science books. One last thing that this science program has really benefited my class is with writing and graphing. Everyone had to make charts and record the growth of flowers with different variables and when graphing with a purpose the children quickly understood what the end results were we are trying to achieve.

During the researcher observation of the science center workshop, one of the instructors Ms. Kate said,

> Let them take a few minutes to go through the kit to find out what is there and what is not available right now. It is very important for you to know what the learning target is going to be and what the kids are going to do. To those of you new to the program, have parents come and have a science night and do some activities with them to inform parents of the importance of what their kids are

going to do and this will help increase the interest of the parents in trying some of the activities at home. For students to know what they will be able to do, you need to have good questions. The suggested time to work with this kit is in the spring or fall so you can collect critters from the schoolyard. According to the law teachers are not allowed to release the butterflies because they do not want to affect the food chain. It might therefore be wise to get larva from outside because you will be able to release those.

During the course of that workshop Ms. Noelle told the teachers the importance of thinking through the unit as they plan the activities to execute with their students. According to her,

> I wanted you to do this activity so you can think your way through the unit. When discussing it you will have the idea of what background knowledge of your students. It will give you an opportunity to assess your students. Science talk is important because it gives students the opportunity to rehearse what they want to write. Students use this time to formulate and think through ideas. It also gives the teacher an opportunity to think about the lesson and this can help you make changes to the lesson that will work for your students. In this particular activity, this is the way it is written and every kid will have a card so they can all have an opportunity to talk. It is also an opportunity to assess the unit at the end. They can be called to put each card on the board in order. Since some cards might be difficult for the students to read you might want to read each card every day until they know what each card means.

This shows that teachers are better prepared to use information learned in professional development activities, if the instructor is able to show how it can be directly used in the classroom and is relevant to their instructional success. As Nugent (2007) found out in her study of teacher's perception of professional development experiences, teachers appreciate professional development that provides practical information and encouraged discussion. They also appreciated professional development that provided resources for teachers to take back to the classroom, and more importantly teachers responded more to instructors who were once teachers themselves and understand what goes on in the classroom. Both of the instructors who I observed their workshops at the science center and the museum were veteran teachers.

Opportunity to experience the unit. During the interview session with teachers, they responded positively to the following question: Do you think this experience will impact your teaching? They emphasized the opportunity to experience inquiry-based activities. In the same fashion when the instructors were asked how their centers help teachers teach science better in the classroom, Commander Kathy from the local museum replied, "I think by giving them the opportunity to experience the mission themselves." Answering the same question, Ms. Noelle from the science center stated that,

> The unit is introduced to the teachers and then we give them kits to try out the activities. The goal is to make sure that inquiry is going on in the classroom. And that kids are being given the opportunity to observe, write, and collect data. Therefore, doing the activities themselves will help the teachers know how to do them with the students, manage their time and know the most important concepts to teach.

A majority of the teachers interviewed, saw the hands-on experience as one of the benefits gained from the museum and science center workshop. Ms. Savannah stated, “the fact that I have done the experiments myself, I know what problems the students might encounter.” Ms. Ann mentioned during her interview that

> At the workshop we were made to do the activities too and this helps you see what problems to anticipate, and how to solve it, some people think they can do it on their own but they really can’t without going for the workshops. The workshop really prepares you to teach and prepare your students for the museum mission.

The workshop instructors and the teachers saw the benefit of hands-on teaching because they felt it allowed students to participate and experience things on their own. Actually trying out the activities on their own made it easy for teachers to apply these new ideas in their classrooms. In my observation of the museum professional development, I noticed in the teacher activity the teachers were taken to the space station where they replicated the experience of working in orbit and some were sent to mission control similar to the one used by the National Aeronautics and Space Administration (NASA) at the Johnson Space Center. Using practical technology applications of mathematics and science, the missions resembles a real space mission. In the space center the teachers formed into their teams and went to work, with the communication team transmitting information to others and trying to read data sent in by other teams. At the science center I also observed the teachers do a card activity. The cards in this activity had information about butterflies on them and the cards were placed on the floor in an egg shape by the instructor. Teachers were then asked to stand around the cards and they were to discuss amongst themselves as to the best way to re-arrange the cards to match the lifecycle of a butterfly. I heard a teacher say, “having you practice doing the activities gets you excited about teaching the unit." Another also remarked that it provided her with hands-on experiences that will enable her to solve possible problems and address challenges. These activities observed during the workshop were also evident in the classroom observation that I conducted. In Ms. Amy's second grade classroom, her science lesson was buzzing with activity of measuring, asking questions about plants and using scientific terms such as investigating, observing and determining what the variables were. The workshop prompted her to reflect on how best to present the materials and lessons to her students. According to her,

> The most valuable part of the professional development was the mini hands-on experiments that we did throughout the day. This gave all of us an idea of how everything was to be presented with expected results. Also, this allowed us to see how each experiment was properly set up.

The same was true in Mr. Frank's class as they came up with ideas of how to take care of the plants, touching the plants and making connections to other subjects. Mr. Frank credited this to going to the workshop and being taught how to get students involved in the lessons. One of the teachers not participating in this study who attended the science center workshop also remarked that;

> Overall, this training helped me to see how fun and exciting learning science can be for kids. It is organized and prepared for you and, best of all, is aligned with our current grade level benchmarks. I think the format of the training, walking us through many of the hands-on activities gives teachers experience with the material that, in turn, makes it easier for us to train others or use in our classrooms.

It is worthy of note therefore that teachers saw hands-on activities as a valuable means of teaching science and having gained that experience at the workshop was a definite advantage.

Teacher confidence. Based on the remarks from some of the teachers interviewed, the presentations by the workshop instructors made them feel confident to teach the units or prepare students for the missions in the case of the museum experience. A thorough review of the interview transcripts revealed the factors that contributed to this feeling of confidence to teach the lessons to their students. One such factor was having the opportunity to experience the lessons first hand as previously noted in my findings. Another factor was having a former teacher model the lessons. This gave the teachers opportunity to plan their own lessons, and manage their time and experiments. In her interview, Ms. Amy mentioned that,

> The first time I went to the one on earth, land and water, they only showed us how to organize the lesson and we did not learn how the experiments were going to work, it was a fiasco. I did not feel we were prepared enough. But the activities we did this time really helped me to know how to teach the unit. I am more confident and I know what the goals are and I am now able to put the focal point on what is relevant to teach.

Ms. Amy felt that having the right person or the workshop instructor who had taught the unit before and done most of the activities was an asset to successful professional development at the science center. Mr. Frank stated, "If I had not gone to any of the professional development at the science center, I would not have known what to do. Now that they have showed us what to do I feel I can present it to the students and I also know what is not relevant." Ms. Savannah also said that,

> I think I am a bit more prepared to teach magnetism because the 4th grade unit is hard and if you know nothing about it you will not be able to teach it. The workshops made me feel more confident and prepared to teach it and simplify it for my students…. The workshop did change the way I teach science because I felt more confident in my abilities

> and prior knowledge about the content area. The fact that we had done almost all of the experiments as part of the training boosted my knowledge, confidence, and interest in the subject.

Thus, learning about the content of the subject matter was really important to Ms. Savannah.

Further analysis of the teacher interview responses revealed that this experience exposed teachers as being vulnerable as learners. This workshop gave them an opportunity to reflect on their own abilities and their participation in this professional development activity gave them the opportunity to explore and accept supportive materials. Their familiarity with the science kit and teacher guide made them more confident to teach the unit.

Teaching tips. Some of the pedagogical strategies employed in these workshops included working teachers through the curriculum materials and modeling of the unit. Examples of these involved giving the teachers points or tips of how to plan lessons, how to know what is most essential for students to know, how to manage materials or the best time to order materials that are needed. One of the core goals of the science center and museum professional development workshops was having teachers actively engage in the planning of the curriculum they are expected to go back and teach in their classrooms. While observing the science center workshop, the instructor Ms. Noelle opined that, "know the activity ahead of time to avoid flops." She went on to state that teachers are not expected to follow the manual verbatim but add or subtract activities based on their students' needs and their style of teaching. It is important for teachers to read the background information in the teachers' manual. She advised the teachers to set up a calendar of when to start and end the unit. The workshop instructor stated that there are 13 lessons; some lessons have more activities than others. She suggested times to help teachers plan and prepare for the lessons. Speaking from experience, she told the teachers how she organized her binder to help her plan for lessons. She said,

> I suggest that you make copies before you do units. Have charts laminated so you are not doing them over and over and use Velcro or magnets, make strips of words, color code words, send home parent letter and whatever you do in the pre-test you must do for the post-test and do not forget to send in your cards for unit materials 2-3 weeks before teaching the unit.

Her major goal was helping the teachers plan for a successful lesson and this was what the teachers told her before the workshop started that they wanted to be able to do when they go back to their respective schools. During the workshop, a teacher commented that, “I want to plan out the first unit, run copies and prepare all materials needed before I jump right in.” They learned that preparation is paramount in having a successful lesson.

The teaching tips given to teachers appeared to be related to the skills learned from the presentation in helping improve their instructional practice. Ms. Savannah mentioned that,

> The workshop clarified much of the unanswered questions I had before starting each unit. The workshop gave me many ideas from which to draw from that would help in the classroom along with the preparation time. Without the training there was an overwhelming feeling of what to do along with how to present it. The teacher's guide was very explanatory, with step-by-step process along with the desired results.

Ms. Savannah stated that she really liked it when the workshop instructor gave tips of how to really make it appropriate for our students. This was observed in the workshop as the instructor stated,

> Write down questions kids ask and then give them opportunity to find answers to their own questions. When you look at the kit, if there is anything you do not think is developmentally appropriate for your kids, leave it and come to it later in the year. Now I will let you watch a video about the stages of the life of a butterfly. This will be an opportunity to teach note-taking skills.

During the workshop discussion session, two of the teachers present at the workshop mentioned that they learned how to choose materials that were age appropriate for their students based on the ideas learned from the workshop. Ms. Amy added that,

> I intend to use what I learned in each experiment and each lesson. Some experiments were very complex but at the training I was given the tools I needed to successfully carry out the experiments with young students. I intend to use the tips and resources they provided to organize my lesson also.

Similarly, Mr. Frank, saw the whole experience as helping him learn how to choose the curriculum materials that will meet the Michigan content expectations. It was also helpful to learn how to adapt the unit to meet the needs of my students and learn to plan lessons ahead of time.

The majority of the teachers in the science center workshop were willing to learn how to effectively plan the unity of study. The walk through and tips of managing the materials was the most reported benefit received from the training at the workshop. During my interview with one of the instructors, I asked what she considered as the most effective workshop experience for teachers Ms. Noelle responded,

> I think actually doing a couple of the activities at their level and remembering how they learned it. When the teachers are able to have their questions answered and they leave

here feeling confident to teach the units because they now know how to organize the materials in advance, manage their classrooms during experiments and collaborate with other teachers in their building who have been using the units. Teachers also learn how to adapt the lessons to fit the abilities of their students and to make the kits work better for them.

Ms. Ann who attended the museum workshop training acknowledged that “the workshop gave tips on how to prepare the students for the mission in terms of how to handle materials, how to manage time and making sure that we know what to expect.” The feeling of being confident comes from the fact that the workshop provided teachers the opportunity to reflect on their planning and learning how to plan for the lessons, acquire new skills and knowledge was one of the major accomplishments of these workshops.

Teacher collaboration. The observations of the workshop and interviews with teachers also revealed that having the opportunity to collaborate with colleagues from other schools was regarded as one of the benefits of attending the workshops. One of the teachers at the science center workshop affirmed that their professional practice was strengthened and their understanding of the unit was deepened because there were teachers in this workshop who had taught the unit before and were willing to share ideas and knowledge about the lessons and activities they had successfully carried out in their own classrooms. A thorough review of the researcher’s field notes reveals that collaboration was very important to 60% of the participating teachers. The teachers saw collaboration as a support system to network with other teachers not necessarily from their own districts. This forum provided opportunity for sharing professional knowledge and opinions and for teachers to compare how they are implementing this new learning in their classroom. It was also obvious that some teachers saw this professional development opportunity as a way of gathering information from veteran teachers and as a means of helping them evaluate their own instructional goals of applying inquiry-based lessons in their science teaching.

During the Science Center observation when teachers were participating in an activity in the butterfly unit, a teacher shared her experience by acknowledging that since kids might not be able to read the cards, teachers can also use it as a center where they can draw the different stages or do it as a small group activity. Another suggested to the other teachers to "model how to do it through an overhead and then connect it to what they do in reading and writing. Make a correlation." Ms. Amy also added that collaborating with other colleagues helped her learn to modify the unit to meet the needs of her students. It was especially helpful to Ms. Amy to meet other teachers who had attended the workshop given by other instructors. According to her,

> They were able to put my fear to rest because they assured me that this workshop instructor was the best and that she had actually taught this unit before. I think that being a first year teacher it was very comforting to know that the person I am listening to know exactly what they are doing.

To further confirm the importance of having the chance to collaborate with other teachers, Ms. Savannah stated that she really liked hearing ideas from other teachers of how to successfully bring this knowledge to her students.

For the most part, during the Science Center workshop observation, the researcher noted that teachers relied on each other to clarify information or obtain other points of view. As the researcher listened to them as they carried out the activities together, a teacher asked if anyone knew how to make an activity work as she has not been successful in making it work. She went on to point out that,

> You think you already know the material until you learn from others other interesting, and kids friendly activities that they have done. This makes you re-evaluate your instruction and I think being able to review your instruction and want to make changes makes you a better teacher.

Sometimes you hear a teacher declare that, "I did not understand what the instructor meant when she said this". Then you notice other teachers explaining what they think it means. Despite the comments made by these teachers, the benefit of collaboration cannot be overemphasized because there was no evidence of collaboration with teachers from other districts after they left the workshops. What was however observed was collaboration and sharing of ideas among teachers within their schools of what they were teaching

Awareness of museum/science center resources. Another benefit of attending the workshops according to the teachers interviewed and observed was being made aware of the museum resources. Teachers indicated that they now have an augmented knowledge of resources available to them and how to use such resources. The participants who attended the museum workshop felt more strongly about the materials they were given and resources made available to their students in general. When asked if the museum workshop would benefit their students, Ms. Harriet replied that, "they are providing additional resources to schools that will give educators valuable choices in how they are going to deliver different parts of the science curriculum to students. The resources will aide educators in making appropriate choices for the needs of their students."

Ms. Bessie, a 36 year veteran teacher, also felt it was beneficial to know about the resources available to teachers. When asked if this experience would make any impact on her teaching, she indicated that, "teachers can bring artifacts into the classroom from the museum to enhance classroom instruction and the Planetarium experience is something that would be difficult to replicate in a classroom setting." Ms. Ann viewed the availability of resources as an asset to improving her teaching and her student outcomes. She believed that,

> At the workshop they gave us more than enough materials and they teach you how to do the activities too and this helps you see what problems to anticipate, and how to solve it, some people think they can do it on their own, but they really can't without going for the workshop. The museum workshop really prepares you to teach and prepares your students for the missions.

During the museum workshop observation many of the teachers present, which included those not participating in the study, emphasized that it was important to be given materials they could utilize in their classrooms for the pre-museum and post-museum visits. Also during the science center workshop observation, being given the kit that included all the materials needed was very important to the teachers. The workshop instructor pointed out that the kits have gone through a lot of changes from the Michigan Curriculum Framework to the new Grade Level Content Expectations. Some of the teachers were very excited about this information, because they did not want to go back to school and have to go through the materials to figure out what was relevant to the Michigan State Grade level Content Expectation (GLCES). One of the science center staff prided herself on being able to provide current materials to teachers. When interviewed, Ms. Noelle, a science center staff and instructor mentioned;

> In the new units, we have identified activities that give kids the opportunity to practice mathematics, language arts content expectations. There is a page in the unit on misconceptions and teachers can use this as an anticipation guide to know the

misconceptions students have so that the misconceptions can be addressed before or during the lesson is taught.

Ms. Savannah also agreed during my interview with her that having the right resources such as the ones that had been provided by the center makes it easy for teachers to prepare and teach the unit. She summed it this way, “The most valuable piece was having a teacher’s copy of the students’ notebook so we could show the students that we had gone through the experiences. Also, the trainers had us make little notes in the margin of dos and don’ts when teaching the lessons.”

Michigan State Grade Level Content Expectations (GLCES). To understand why this was of significance to teachers, one must understand the Grade Level Content Expectation. According to the Michigan Department of Education,

> Reflecting best practices and current research, the Grade Level Content Expectations provide a set of clear and rigorous expectations for all students, and provide teachers with clearly defined statements of what students should know and be able to do as they progress through school. (2004, v.1.09, p. 3).

For teachers to be successful at their job, it is important for them to know what is essential for their students to know and be able to do. With this in mind it was very important to Ms. Harriet that the fieldtrip and workshop to the museum must meet the Michigan GLCES. She only values a professional development that aids her to meet the state GLCES. It was evident in her classroom observation and interview that meeting the science content expectations was a priority to her and her students. She observed in my interview with her that, “the museum is providing the Michigan Grade Level Content Expectations for these programs which frees teachers up in the planning stage.” When she was asked how going to the workshop would benefit her students, she responded thus,

> My fifth grade students would be exposed to the GLCE's that were covered in the handout that I received from the museum. Before deciding to go to the museum it was important to us as a school that whatever we are going to learn from the museum is relevant or meets the Michigan GLCES.

In emphasizing the significance of the content expectations, she added that, “realistically, the more their educational program follows the GLCES, the more teachers will participate. If they put out what GLCES their program covers, the more the teachers can match it to what their GLCES are.” In answering the same question, Ms. Bessie, a veteran who attended the museum workshop, also feels that, “if they offer programs that are correlated to the Michigan GLCES I think more teachers will attend.” During one of the Science Center observations, one of the teachers present at the workshop commented that, “I think the strength of the program is that they have a rigorous curriculum that is aligned to the state content area expectations, we get materials that are current in the GLCES.” Thus, the professional development workshop experience helped to fulfill the Michigan content expectations students are expected to know and be able to do in science.

Theme 2 - Why it did not improve instructional practice. In the case of the teachers who went to the museum, the workshop was a preparation strategy that included content familiarization to get students ready for the voyage to mars mission simulation. Thus as part of the preparation, teachers had to make sure their students knew the vocabulary, their jobs and how to communicate with their team members. Based on the in-depth discussion with the participating teachers some of them did not think the workshop made any significant improvements to their instruction. The teachers in this study who felt strongly about this were Ms. Bessie, Ms. Marie and Ms. Harriet. They expressed that the factors which are discussed contributed to the workshop not making any impact on the way they teach science. They agreed that the workshop at the museum was beneficial to their students' understanding of what to do at the museum during the fieldtrip. After a careful review of the researcher's field notes the following sub-themes became obvious as to why these three teachers felt that way. They already had a strong background in science; the workshop was too short to make any significant impact; no new content was really learned; there was no follow up activity after the workshop; and time constraints. It is worthy to note however, that some teachers who thought they benefitted from the workshops also made comments that were relevant to be included with the views of these three teachers.

Strong background in science. As a science major, Ms. Bessie's formal science training has been quite extensive in her 36 years in the teaching profession. As noted earlier in this chapter, she has attended much professional development in science training and has led professional development trainings herself. She feels her success with the museum science is as a result of background in science because she has taken numerous extra hours of science courses from the local university since she began teaching. She is also involved in her school's science professional learning community and she has had the opportunity to participate in a number of in-service workshops. In her current position as the department chair in her building, she is responsible for making sure that other science teachers know the science curriculum and what their students are expected to know. She also stated during her interview "I have had training in data streaming, oceanography and have worked in a project called Project Wet with the National

Science Foundation." Based on her comments and the programs she has been involved with, it was quite obvious she was a teacher with lots of experience.

The same is true of Ms. Harriet who majored in science in college and attributes her success in teaching science to the methods course she took and the in-service workshops she has attended during her 14 years of teaching. Her experience with science in college contributed to her feeling confident to teach science. The interview session with these two teachers indicated that they did not acquire any new knowledge from the museum workshop though they felt it was beneficial to having their students ready for the fieldtrip. Ms. Harriet reported that,

> The workshop didn't really change my attitude about teaching science. I like teaching, and so my attitude hasn't really changed. I guess you could say that I think that it might change the students' attitude about science though. I had a number of kids say to me that they are now interested in a career with NASA. Now, I know that kids will change their minds frequently, but I still think this field trip had that kind of effect on them. I don't believe I could have accomplished the same thing in my classroom. That is very important to me and would affect how I plan my teaching.

Ms. Marie who also majored in science during her undergraduate years also credited her confidence in teaching science to all the science workshops and science courses she has been involved with since she started her teaching career. She also stated that,

> As a result of the extra science courses I have taken over the years I have always made an effort to know the science content of what I teach and I try to make hands-on learning a part of my classroom routine.

No new content. For teachers to improve their instructional practice, it is important for them to learn new content that resembles what they hope to provide for their students (Davis, 2002; Loucks-Horsley et al., 2003; NRC, 1996). It is therefore worth noting that the researcher thought learning new content would be one of the focuses of the workshop. Some teachers did not think they learned anything new with regard to their school curriculum. According to the teachers, the workshop was rather an attempt to make teachers familiar with the fieldtrip procedure and how to manage their students when they brought them to the museum. When teachers were asked what they gained from the museum workshop in terms of content knowledge, they did not feel there was any increased understanding of any new science content. Through her response to the question asked, it was obvious that learning new content that is related to the curriculum was very important to Ms. Harriet. She however did not feel she got that from the museum workshop and was not really expecting to gain any new science content. To Ms. Harriet, the purpose of the workshop was to help prepare her students for the fieldtrip. This is evident from her statement that,

> I don't know if attending the workshop has increased my content expectations in science. I can't say that it has changed my teaching of the science curriculum except that I will add this fieldtrip experience to my school year. My teaching is guided by research - what has been proven to be most successful in helping students learn. This workshop was based on preparing students for a field trip, helping them be successful when they are participating and then follow-up reflection. I did not attend the workshop with the hopes of learning new teaching methods. I believe they accurately explained what their goal was and they fulfilled it.

A review of the literature revealed that focus on academic content is one of the common elements of a successful professional development (Garet et al., 2001). Also citing the NRC, Melber and Cox-Petersen (2005) stated that teachers need to learn “essential science content through scientific inquiry as one of the professional development standards" (p. 4). Yet the teachers who attended the museum professional development program did not feel that they learned any new content. When asked during the interview if any content knowledge was gained from the workshop, Ms. Marie responded, "Actually no. I didn't learn anything new in the science content area from the Professional development, just some good ways to deliver and prep the students." The same was true for Ms. Bessie when she was asked the same question. She said, "No. However, it did give me a set of activities that I could use as formative assessments to determine if students were achieving the learning goals I set for the unit." Clearly, the teachers who attended the museum workshop did not dispute the significance of the workshop in helping them prepare their students for the fieldtrip to the museum; they did not however think they gained any meaningful experience in terms of learning new content knowledge. During the interview sessions and during the researcher's observation of the workshop, they explained that their students would be well prepared for the fieldtrip because of the insights they had gained from the workshop. For these teachers, being able to manage their students' behavior and fostering students' interest in the voyage to Mars program seemed more important to them than learning new content. It is however possible that these teachers felt this way because they have science degrees. Other teachers with degrees in other disciplines might feel differently from these teachers.

No follow-up activity. Of all the teachers observed and interviewed some of the ones who attended the Science Center agreed that it was important to have a follow-up activity for teachers to reflect on their professional development experiences. They added that having the opportunity to discuss with instructors and other colleagues about how their instruction was going seemed to be very valuable to teachers especially the less experienced teachers. To them it was just not enough to obtain the information the first time and be expected to know how to implement the new learning without coming back to see how everything was going. Davis (2002) in her exploration of issues that surround teacher learning of new practices noted that "support from research and professional development teams is critical as teachers begin to incorporate new approaches…teachers must have ample time and support for reflection, interactions with other teachers, and further learning opportunities" (p. 6). Echoing this belief, Loucks-Horsley et al. (2003) stated that "teachers must have supported opportunities to become aware of the new curriculum, learn to manage materials in the classroom, learn any new science or mathematic content, teach the new curriculum, and assess both their own and their students learning" (p. 129).

When the workshop instructor at the Science Center was asked during her interview if their program had any follow-up activity, she responded by saying, "hopefully the teachers are going back to their classrooms tie it all together for us. Also there is no way to know what teachers do in the classroom." When the researcher further probed if they have any communication at all with the teachers after they leave the workshop, Ms. Noelle again said "most of the time they only call if they need someone to model a lesson or have trouble with materials." She went further to add that,

> There is no control of what goes on in the classroom. You may send the unit but teachers may not open it, no accountability once they are at the building. Even if they take all of it you cannot make the teachers teach it.

This is the reason why the teachers felt it would be beneficial to them to get some continued support from the center to be able to implement the instructional strategies learned at the workshop. The teachers who attended the Science Center workshop had more problems with this issue, because when they were asked during the post workshop interview what further professional development support they need in order to implement the strategies learned, Ms. Amy replied,

> Perhaps a couple of months after initial trainings a shorter follow- up / refresher course discussing what works, what doesn't, what can be improved in our teachings, etc would be worthwhile. It would also be nice to actually see how other teachers manage their activities and I wish we could go back for a refresher workshop to discuss what worked and what did not.

Although Mr. Frank had many positive things to say about the workshop experience, he did feel having a follow-up activity was important. This is reflected in his answer to the same I question asked Ms. Amy. According Mr. Frank,

> I think it would be a good idea that some form of follow-up training be provided. Possible topics could be things that have been added or changed within the last year. Also a review session for teachers that have had the training to answer questions or find solutions to problems that they have encountered within the past year.

The lack of communication with the teachers after they leave the workshop was also confirmed by the workshop instructor at the museum, Commander Kathy. She said that, “very little communication goes on between teachers and the museum. We send out newsletters three times a year. Teachers call only when they have problems. There is actually no two-way communication going on, outreach is not encouraged.” As research has revealed, for teachers to continue to implement all the strategies they learn from professional development programs, it is critical for them to receive support or other learning opportunities. If they are expected to incorporate these new strategies to their everyday instruction, they must be given a supportive environment to do so (Davis, 2002; Loucks-Horsley et al., 2003). Ms. Savannah who had no problems with the workshop also felt it was very important to continue to have support from the centers in order to be able to implement what was learned. In her interview she declared that,

> There should be an introductory training and they should continue throughout the school year. If teachers only see it or hear about it once, chances are they may not continue to work on it. It is more effective to have continuous training and opportunities for teachers to discuss their successes and failures and how to improve.

Loss of a full day of teaching. Ms. Harriet had mixed feelings about attending the workshop during the school year because she felt it took her away from her students. She was one of those who suggested that professional development should be held before the school year starts. While she thinks the experiences her students would have going to the museum was critical to their schooling, she did not appreciate being away from her class and her students just to attend the pre-visit workshop. During the follow-up interview, she explained that,

> I don't believe there is any one best time to have workshops for teachers. It can be effective to have workshops before a school year starts so that new ideas can be implemented right away as classroom procedures and practices are established. It also eliminates the need to pay for substitute teachers and avoid disruption to students' routines.

Ms. Bessie who has been going to the museum for the past 10 years appreciated going for professional development programs that are beneficial to her students and improved her science teaching skills. She however does not appreciate investing a full day that she should have been teaching her students. She also was not fond of the time spent preparing for a substitute teacher to take her place when she was gone. During her interview, she explained, "It's always difficult to leave the classroom. It's hard to design sub-plans that will allow students to continue to move forward. I prefer going to conferences and workshops during the summer." Ms. Marie also felt very strongly about leaving her students during the school day to attend a professional development workshop. She would rather have the workshop during the summer before school starts, she stated her feelings in her interview thus, "most of the time I feel that PD is best offered before the year begins, when the teachers are able to discuss and process the information. This allows staff to figure out when it is best to incorporate new ideas into an already packed school year."

Time constraint. Most of the teachers involved in the study had strong desires to do all of the activities they had learned with their students in the classroom. One of the teachers saw time as a constraint to implementing the strategies. Some admitted that having enough time to plan and to think about the new strategies was an obstacle to having a successful workshop experience. Time was Ms. Marie's greatest barrier; she thinks there is never enough time to do all the activities because there is so much to do during the course of the school day. In her opinion, "having the needed time to vary activities and techniques would be the greatest support that I need." As noted in their book *Designing Professional Development for Teachers of Science and Mathematics,* Loucks-Horsley et al. (2003) noted that it is essential that teachers are given enough time to learn and try out new strategies. Klingner (2004) also noted that time constraints was one of the factors that 'impeded their sustained use of practices" (p. 254). She suggested this is as a result of other things competing for teachers' time during the school day.

Survey

Science Teaching Self-Efficacy Belief. As part of this study, teachers completed a (STEBI) survey (Riggs, 1988 and adapted by Ramey-Gassert, 1993 & Jung, 2004) as an assessment of their beliefs about their science teaching ability. The STEBI survey used for this study is a collection of 20 items scored on a 5- point Likert style scale (5= Strongly Agree, 4=Agree, 3=Uncertain, 2=Disagree and 1=Strongly Disagree). The 20 items assessed the teachers' ability and confidence to teach science effectively and their ability and confidence that effective science teaching produces positive student outcomes.

An analysis of the STEBI scores was done to look for triangulating evidence that established or invalidated the themes that emerged from the transcribed individual interview. Results revealed that a majority of the teachers (5 out of 6) were confident about their ability to teach science effectively and that teachers with effective teaching strategies can help students learn science better (M=3.83, SD=.294) (see Appendix D for Group Frequency table). It is important to remember that though teachers responded positively to the questions, the degree to which they responded varied. Ms. Amy who was a first year teacher was more uncertain about her belief and her ability to confidently teach science. When further prompted during the interview session why she was uncertain in her response to statement # 5, which was "I know the necessary procedure to teach science concepts effectively" Ms. Amy said "As a new teacher, I am still learning how to organize and present the information to students." It is also significant to note that due to time constraint only one survey was administered. There was no time to obtain a pre- and post- STEBI scores as it was nearing the end of the school year. There was therefore no way to tell if the workshop she attended made any real difference in her efficacy belief.

An examination of the frequency data also revealed that on survey question # 18, "Given I choice I would not invite the principal to evaluate my science teaching" teachers disagreed with this statement (50% disagree, 50% strongly disagree; M=1.5, SD=.55). To further provide an insight to the teachers' responses they were asked to explain what their responses meant during the individual interviews. As was stated earlier in this chapter, Ms. Savannah, a teacher who saw the workshop as being beneficial, attributed her confidence to invite the principal observe her science teaching to the workshop she attended at the science center. She stated that,

> The workshop did change the way I teach science because I felt more confident in my abilities and prior knowledge about the content area. The fact that we had done almost all of the experiments as part of the training boosted my knowledge, confidence, and interest in the subject**.**

On the other hand, Ms Bessie representing the teachers who felt the museum workshop did not improve their instructional attributed her confidence to 36 years of teaching and having a strong science background.

In the interview sessions, teachers also gave responses that were synonymous to the results of the survey. For example on statement # 16 “I have the necessary skills to teach science” (3= strongly agree, 2=agree and 1=uncertain). While the frequency of response was different, two factors were examined as possible reasons for the positive responses, attending the museum or science center workshop and the number of years in the teaching profession.

Individual interviews with the participants also shed light on how teachers view professional development programs. The goal of this study was to find out if the professional development programs offered by a Midwestern museum and science center improve elementary teachers’ instructional practice. In response to the survey statement “ I am continually finding better ways to teach science” teachers were split over their degree of agreement (3=strongly agree, 3=agree). The researcher concluded here that teachers generally are always seeking ways to improve their instruction. Ms. Savannah provided more insight by stating that, “I feel professional development is an extremely important piece of the teaching profession that can have a direct effect on the students and their learning." As a teacher who fell under the group of teachers who did not think the museum workshop improved or added anything new to her instructional practice, Ms. Harriet acknowledged the significance of finding better ways of teaching by stating, "I am always seeking professional development that would assist in making me more effective at my job. Professional development can also be enlightening, inspiring, motivating and encourage further growth."

Overall Conclusion of Findings

The qualitative case study results offer narratives of six teachers and a museum and a science center workshop instructors' perception of the professional development experiences and programs provided by the centers. Each participant described what was beneficial and what was not so beneficial to their instructional practices. This chapter discussed the findings and results from observations, interviews and survey of teachers who participated in a museum and science center professional development workshops. Through the observations and interviews, the following themes merged 1) workshops were beneficial and 2) why it did not improve instructional practice. Themes were further explored to reveal the contributing factors or subthemes. As for theme one, teachers felt the following factors were gained from the workshops, scientific knowledge, opportunity to experience the unit, awareness of museum resources, teacher confidence, opportunity to collaborate with other teachers, teaching tips and the alignment of curriculum to the state content expectations. Theme 2 revealed factors that contributed to some teachers not feeling the workshops did not improve their instructional practice, and they include, strong science background, time constraint, loss of a full day of teaching and no follow-up activity.

Through the results of self-efficacy survey and the individual interview data teachers in this study clearly made their perceptions about the professional development and their beliefs in their ability to teach science and improve student learning known. Their efficacy beliefs may be due to the workshops provided by the museum and science center or the number of years in the teaching profession. Overall, teachers involved in this study felt they received experiences that would be either beneficial to them or to their students and they particularly enjoyed the inquiry-based activities that were conducted in either the museum or the science center. There were, however, areas they felt also needed some improvements to make it a more rewarding experience for them and their students.

CHAPTER 5

Discussion

Introduction

This research set out to examine how the instructional practices of six elementary school teachers were affected by the professional development programs of a museum and a science center located in two Midwestern cities. The findings of this research reveal an array of opportunities that informal science education programs provide science teachers. This is consistent with much of the existing literature related to science learning in out-of-school settings and professional development programs. Garet et al. (2001) stated that despite the growing literature on professional development, "surprisingly little attention has been given to what teachers actually learn" (p. 923). In recognition of the limited literature that exist, this study adds to the research on the training of in-service teachers in non-school settings such as science centers and museum professional development programs and their ability to improve the self-efficacy and confidence level of science teachers in elementary school. Finally, it is the hope of this researcher that this study encourages more research on effective professional development programs for in-service teachers and that more teachers will continue to use the resources provided by out-of school settings such as museums and science centers.

To analyze this research question, How do the professional development programs at museums and science centers help teachers improve their instructional practice with regard to teaching inquiry-based science instruction?, multiple data collection methods were employed during this qualitative case study, including semi-structured interviews, workshop and classroom observations and a survey of teachers' efficacy beliefs of the six participating teachers. These methods provided extensive data about how teachers felt about attending the professional development programs organized by science centers and museums.

Results after analysis indicated that there were two emerging themes. There were teachers who believed that the workshop was beneficial and those who did not think the workshop improved their instructional practice. To strengthen and add supportive evidence to the data collected from workshop, classroom observations, teacher interviews, and a teacher self-efficacy belief survey was administered. Results were obtained using the STEBI instrument that has been used by other researchers (Riggs, 1988, Ramey-Gassert, 2003, Jung, 2004) Careful examination of the results obtained from the frequency distribution of their responses indicated that the teachers in this study had positive responses to the questions asked regarding their ability to teach science effectively. This chapter describes the collective perceptions and feelings of practicing teachers, how these perceptions are connected to relevant literature reviewed in this study, implications for science teaching practice, museum and science center education, and recommendations for further research.

Discussions of Findings

As research into science learning in out-of- school settings such as museums and science centers has continued to grow so has the need to explore the contributions and roles of these centers to science education (Anderson et al., 2003; Cox- Petersen et al., 2003; Falk & Dierking, 2001; Kisiel, 2003; Rennie et al., 2003). There is however limited research on the professional development programs these centers have for elementary school teachers and the impact of the programs on their instructional practice. This study examined the workshops organized by two

Midwestern museum and science centers to see if they helped improve the way elementary school teachers teach science in the classroom. The research question sought to indentify how professional development programs in a museum and science center affect the instructional practice of elementary school science teachers. Seven factors were identified from teacher observations and interviews as beneficial to teachers who attended the workshops organized by the museum and the science center (see tables 3 and 4). In examining the data, it became obvious that the participants could be divided into two groups based on their views regarding what was learned at the museum or science center workshops. There were those that believed that the workshops were beneficial and those who did not feel that the workshops improved their instructional practices. Table 3 summarizes what teachers saw as benefits of participating in the workshops and table 4 summarizes why some teachers felt that the workshops did not improve their instructional practice.

Result of observations. Though the observations did not go on for a long period of time, results indicate that teachers observed were using what they had been taught in the workshops in their classrooms. Through further interviews with teachers, the researcher found out that the success of the workshops depended on the instructor conducting the workshop. A teacher commented that they have attended some workshops that the instructor did not know or present the material well. The result of this study also show that professional development programs organized by the museum and science center help teachers feel more confident and prepared to teach the science units to their students. In addition to the feeling of confidence is the fact that teachers are going back to use these teaching methods in their classroom. This is due to their engagement with hands-on activities at the workshops. Participants reported that going for the workshops prepared them to effectively teach the units to their students. This was especially true for one participant who was a first year teacher. According to her, “I wish I could attend the workshop before teaching every unit. It will make me more comfortable to teach science.”

Research suggests that an effective professional development program is one that helps teachers understand and implement new strategies (Davis, 2002; Klingner, 2004; Lieberman, 1995; Loucks-Horsley et al., 2003). In their study of professional development programs, Loucks-Horsley et al. (2003) recommended that in “developing proficiency in mathematics and science requires learners to develop conceptual understanding as well as procedural information in the subject” (p. 33). It is also important to note that educational reformers (Boardman & Woodruff, 2004; Darling-Hammond, 1998; Davis, 2002; Klingner, 2004; Loucks-Horsley et al., 2003) characterize effective professional development as one that provides teachers 1) opportunity to build their content knowledge, 2) opportunity to experience and discuss the materials, 3) collaborate with colleagues, 4) linked to state goals, and 5) promotes teacher confidence.

Scientific knowledge. This study shows some relationship between the museum and science center professional development programs and the increase in teachers’ science content knowledge. Further reflection reveals that these results are consistent with past research findings. Some research findings suggest that any professional development program that focuses on content knowledge is significant to improving teaching practice (e.g. Garet et al., 2001). They suggested that focusing on “subject-matter content” (p. 924) is important to changing instructional practices.

Table 3

Benefits Identified in this Study-Group A

Benefit	Description
Scientific knowledge	Teachers see the workshops as opportunity to increase their scientific knowledge
Opportunity to experience the unit	Teachers see the workshops as opportunity to try out the activities first before teaching it to their students.
Teacher Confidence	Teachers see the workshops as events that boost their confidence to teach science.
Teaching Tips	Teachers see the workshops as opportunity to get teaching tips and how to organize unit materials from workshop instructors.
Teacher collaboration	Teachers see the workshops as opportunity to collaborate and learn from other experienced teachers.
Awareness of museum/science center resources	Teachers see the workshops as events that made them aware of the resources available to them at the museum and science center.
Meets Michigan State Grade Level Content Expectations	Teachers appreciate the fact that what was learned at the centers was aligned to the Michigan State Science Content Expectations

Table 4

Why It Did Not Improve Instructional Practice- Group B

Reasons	Description
Strong background in science	Some teachers believed they did not learn new content because they already had a strong background in science.
No new content gained	Some teachers believed that the workshops did not improve their instructional practice as they did not learn any new content from the workshops but felt their science content knowledge was refreshed.
Loss of full day of teaching	Some teachers did not like the fact that the workshops were held during the school day.
Time constraint	Some teachers there was not enough time given to implement all they learned from the workshop.

Four of the workshops participants in this study acknowledged gaining some scientific content knowledge through the lessons given by the instructors. However, as stated in chapter four, teacher participants revealed in the interview sessions that their science content knowledge was refreshed and not that new content knowledge was really gained. This left the researcher with more questions such as, how can they say they gained new knowledge if the workshops only reminded them of what they already knew? It can therefore be concluded that the participants' scientific content knowledge was verified and strengthened through their participation in the museum and science center professional development programs.

A study (Melber & Cox-Petersen, 2005) about teacher professional development and informal learning noted that workshops give teachers opportunity to "enrich their scientific content knowledge" (p. 103). Two of the participants, Ms. Savannah and Mr. Frank, noted that the science center workshop gave them the opportunity to revisit what the learned in college. The science center experience according to them, reminded them of what they had learned and made it easy to learn what their students needed to know. They both suggested during their interview session that the workshop expanded their science content knowledge. It stands to reason that teachers should continue to seek professional development opportunities that expand content knowledge as they find ways to improve their science instructional practice. This study revealed that teachers' content knowledge is an important component of professional development program. This is especially true for content that is aimed at improving their instructional practice. This is supported by Garet et al. (2001), as their research suggests that improvement of teacher knowledge is connected to how students learn.

Opportunity to experience and discuss materials. The literature suggests that the core feature of an effective professional development is to give teachers the opportunity to actively participate in workshop activities (Garet et al., 2001; Lieberman, 1996; Loucks-Horsley et al., 2003). Teachers in this study indicated that they valued the opportunity to experience the unit and discuss the materials with colleagues. Garet et al. (2001) in their study found out that when teachers are actively engaged in the workshop process they are learning how to teach the new curriculum and acquiring new methods to teach it to their students. As Mr. Frank noted,

> The most valuable part of the Professional development was the mini hands-on experiments that we did throughout the day. This gave all of us an idea of how everything was to be presented with expected results. Also this allowed us to see how each experiment was properly set up.

In examining the motivations and strategies for conducting fieldtrips, Kisiel (2003) noted that hands-on experience brings the "curriculum to life." This study of elementary school science teachers reveals the same belief. The assumption is that hands-on experience enhances teachers' interest and understanding of how to present the concepts to their students.

Teacher confidence. The results of this study show that professional development workshops organized by the museum and science center helped the teachers feel more confident to teach science in the classroom. This point of view is supported by several studies on the effect of professional development on instructional practice. Price and Hein (1991) evaluated the effect of science programs by museums on students and teachers. They found out that in a period of two to three years teachers reported increased confidence in their ability to integrate what they learned at the museum workshops to their science teaching. The teachers in the current study also reported having positive outcomes from the museum and science center workshops they attended. They felt these outcomes would improve their science instructional practice. Also data from the self-efficacy survey support their positive attitude, as all the participants disagreed with the statement "Given a choice, I would not invite the principal to evaluate my science teaching." Supporting this feeling of confidence is the study by Jung (2004) about the importance of out-of-school settings on pre-service teachers and in-service teachers and their ability to teach science. The study reported that pre-service teachers reported feeling more confident after their participation in museum pre-service training. Findings from this study hold promise for science teachers interested in participating in future workshops offered by the museum or the science center.

Alignment to state goals. Another core feature gained from this study is the perception of teachers about the curriculum that was offered. Through observations and interviews with teachers, it was learned that the fact that the curriculum provided during the workshops was already aligned to the Michigan State Grade Level Content Expectations (GLCES) was important to teachers. In this age of standards-based teaching, it was imperative to the teachers that the curriculum materials provided during the workshops be aligned to the state standards. Some teachers felt that it was very important because it would encourage them to use what they learned. Several researchers also found out that teachers were more willing to implement programs that are already coordinated with their curricula as it increases their ability to be committed to the program and facilitates teachers' efforts to improve their practice (Cohen & Hill, 2001; Garet et al., 2001; Loucks-Horsley et al., 2003; Price & Hein, 1991).

Teacher collaboration. Teacher collaboration was also an important benefit gained by teachers in this study. Teachers reported that the museum and science center workshops provided them the opportunity to learn from other experienced teachers also attending the workshops. In a study of elementary programs in extra school science institutions such as museums and science centers, Price and Hein (1991) came to the conclusion that students did not only benefit from the institutions but teachers as well. They stated that teachers described in positive terms that the workshops gave them opportunity to learn from each other. In another study, Lieberman (1995) stated that teachers need professional development programs where they can develop a "community of shared understanding that enriches their teaching" (p. 595). Findings in this study are consistent with research that acknowledges how teachers feel about the support they receive from colleagues from other school districts, through sharing of materials, advice and teaching tips (e.g Garet et al., 2001; Guskey, 2009; Loucks-Horsley et al., 2003; Nugent, 2007; Ramey-Gassert, 1997).

Not beneficial. The findings of this study suggest that despite the positive experience emphasized by a majority of teachers after attending the workshops, two teachers felt that the experience did not improve their instructional practice. Teachers like Ms. Bessie and Ms. Harriet did not think any new content was learned at the museum as they saw the workshop as an opportunity to prepare their students for the fieldtrip, which I think is a worthwhile outcome. While studies reveal that for a professional development program to be considered effective, it has to have a follow-up activity (Guskey, 2000, Loucks-Horsley, et al, 2003), teachers in the current study wished there were follow-up activities to encourage teachers to use what they learned at the museum and science center workshops. Findings also reveal that four teachers desired more time to implement the new learning. Giving teachers enough time to effectively apply new learning is supported by other researchers (Guskey, 2000, Loucks-Horsley et al., 2003, Ramey-Gassert, 1997). Another teacher in this study, Ms. Harriet did not appreciate taking time away from her students for a full day. She appreciated workshops that are conducted before the beginning of the school year. More importantly, teachers who did not see the workshops as beneficial based their reasons on the fact they already had a strong science background. It would appear that teachers who already had strong science backgrounds did not gain much in terms of content knowledge from the workshops.

Changes in self–efficacy beliefs. Self-efficacy according to research refers to being able to personally assess one's belief and ability to implement behaviors such as teaching science effectively (Jung, 2004; Ramey-Gassert, 1993; Riggs & Enochs, 1990). In this study the STEBI survey was administered to assess changes in science teaching efficacy after attending the museum and science center workshops. Changes in participants post workshop STEBI scores were analyzed using a simple frequency distribution. The data suggested that teachers had a positive attitude towards science teaching. It is not known however, if the museum or science center experience is the primary reason teachers had a positive self-efficacy belief towards the teaching of science or teach science effectively. A teacher at the science center workshop simply said, "though this training made the teaching of science easier, my attitude toward science has actually been pretty positive and I have always felt confident to teach science due to my educational training." It is also plausible that the teachers' efficacy beliefs can be linked to other factors as most of the teachers in the study already stated. Some of such factors include strong science background and other science related experiences. This however left the researcher with another question such as did the survey really inform the researcher if these beliefs shaped the way the participants teach science?

Limitations of the Study

As with most studies, there were limitations with this study. Several factors created challenges for me to thoroughly explore the effects of the museum and science center workshops on the instructional practice of elementary school science teachers. These challenges included the time constraint to observe the participants; small sample size; lack of pre- and post- self-efficacy survey data and perhaps my personal bias as a trained elementary school teacher. An important factor was that this study was limited in duration as it was conducted during the fourth quarter of a school year. If the study had been conducted for a longer period of time, more classroom observations and interviews would have been conducted. Existing literature suggests that teachers need time to implement the targeted practice (Guskey, 2000; Kent, 2004; Klingner, 2004; Loucks-Horsley, Hewson, Loucks-Horsley et al., 2003; Love & Stiles, 1998). They also need time to reflect on their instructional practices and to practice what was taught during the professional development program they attended (Kent, 2004).

The study acknowledges the use of a small sample of teachers who volunteered to participate (six teachers & two workshop instructors). Most teachers approached did not feel they had any time to be fully involved in the study as it was nearing the end of the school year. The view of the six teachers may not be enough to over-generalize about how teachers feel about the workshops they participated in, nevertheless, the study reveals that museums and science centers are having an impact in the teaching of science in elementary schools. Discussions I had with teachers who participated in the workshops that I attended, but did not participate in the study confirmed the view of the teachers in the study that the workshops were beneficial to them.

As I pointed out in the previous chapter, most of the participating teachers had some science background. It is, however, difficult to know why teachers with no science background did not want to participate in the study. Is it because of fear of the administration finding out about their lack of strong scientific knowledge, or is it because of their lack of confidence in their effectiveness in the classroom? In order to find answers to these questions, an examination of this group of teachers might reveal the reason for their lack of interest in participating in the study.

Another limitation of this study is that it is not known if the participating teachers will continue to incorporate what they learned in the workshop in their science teaching. There was also no way to validate the contribution of their workshop experiences on the science education of their students as students were not interviewed during the course of this study. The focus of the study was directed at the experiences the participating teachers had at the museum and science center workshops. As students were not part of this study, there was no attempt made to find out if teachers' participation in the workshop experience had any impact on student learning. There was also no way to know if it had a long-term effect or improved their students' scientific knowledge over time as this was not a longitudinal study. It should be noted that these questions remain as research questions for a follow-up study in the future.

One important limitation in this study that was known before this study started was my own personal bias. As a trained elementary school teacher, who had at one time provided science instruction to elementary school students, I knew it would be a challenge to be objective. The decision was therefore made ahead of time to take reflective notes that would be later validated by the participating teachers themselves. This was done in an attempt to reduce my own bias and to be an objective observer and not a critic.

A final limitation is that only two themes emerged from the research findings. It is not known if additional themes might have emerged if there were more participants. It is also possible that with a greater number of subjects, some of the subthemes might have become more prominent.

Implications

Despite the above-mentioned limitations, this study adds to existing literature on informal science and their contributions to the teaching of science. Participants in this study which included six teachers and two museum and science center workshop instructors, provided insights into their perceptions of the workshops organized by these two centers. Based on the findings of this study, there are several implications especially for elementary science teachers who plan to attend the museum or science center workshops. This study revealed that elementary science teachers have positive opinion about the workshops that helped improve their content knowledge and increased their confidence to teach science effectively. They also supported the workshop that provides time for them to participate and practice through hands-on experience the content they are required to teach their students.

The study also revealed that teachers prefer a professional development program that provides time for them to collaborate with other colleagues. Another important factor recognized by teachers in this study is the fact that the activities they participated in during the workshops were aligned to the Michigan State Grade Level Content Expectations (GLCES). The teachers also acknowledged that more follow-up was needed to increase their ability to improve their instructional practices.

As for the instructors at the museum and science center, they prided themselves in their ability to provide teachers with the opportunity to experience activities for themselves, helping them get their students ready for the trip or mission; they provide a rigorous curriculum that is aligned to the state content area expectations and get current resources to teachers. The science center instructor also stated that they train administrators so they know what good science teaching should look like in the classroom and to make it easy for administrators to know what to look for during teacher observations.

It is also relevant to note that despite the positive opinion about the workshop experience there were teachers in the study who did not feel they learned anything new because of their strong science background. The content knowledge taught was not new to them. Also there was no time to implement all they were taught at the workshops. As a result the teachers felt the day should have been better spent in their classrooms. Most of the teachers (both participating and non-participating) also stated that having a successful workshop depended on who the instructor was. Nine of the 12 teachers who attended one of the science center workshops complained of one of the instructors who did not explain the concepts well to them. On their part the instructors (two) in the study acknowledged that, they do not have any control over what goes on in the classroom as there is no accountability once the units and resources are sent to the school building. One instructor Ms. Noelle rightly stated that they cannot make the teachers teach the curriculum. It is however, hard to know if teachers are using the materials given them because of lack of follow up or visit to the schools.

However, in its many forms, professional development programs have become an integral part of practicing teachers' in-service training because of its emphasis on giving teachers the tools they need to improve their instruction. The result of this study show that there is definitely a relationship between the kinds of professional development offered by the museum and science center and other factors for effective professional development that have been advocated by proponents of what constitute effective professional development (Darling-Hammond & McLaughlin, 1995; Garet et al., 2001; Loucks-Horsley et al., 2003). The teaching practices encouraged by the museum and science center programs also align with the kinds of practices that have been advocated by science reformers and the National Standards for science teaching (NRC, 1996).

Recommendations for Further Research

There are many other ways this research can be extended. First, more detailed data including a pre- and post-workshop questionnaire need to be collected about what really benefits science teachers and how they use what they learned from the workshops organized by informal institutions workshops (such as the museum and science center workshops). In my experience I observed a small sample of the teachers who attended the workshops, which does not constitute the general view of all the teachers who attend such workshops.

Another direction for future research is to find a way to evaluate the workshops to ascertain their significance to the effectiveness of teaching of science in elementary schools. The instructors in this study acknowledged the fact that there was no way of knowing the impact of the workshops on teachers' instructional practice as they do not do follow-up classroom visits. As the research on the importance of museums and science center continues to grow, a longitudinal research is needed to establish whether the workshops organized by these centers actually have an impact on science teachers' instructional practices.

This study shed some light on teachers' perspectives on museum and science center workshops and their benefits to elementary school science teachers. Further examination of the degree of impact through qualitative and quantitative methodology could provide a clearer picture of the museum and science center workshop experience.

In this study, recruitment of participants was done during the workshop I attended which was in the middle of the 2008 and 2009 school year. The time constraint contributed to the low number of participants in this study. It is therefore recommended that for future research teachers should be recruited earlier in the school year as it will give the researcher more time to do many classroom observations before and after the workshops. It is my belief that this might provide a more detailed account of any instructional improvements teachers make and if the improvements can be attributed to the workshop attendance.

This study also reported positive self-efficacy scores for participating teachers based on their post-workshop responses to the STEBI survey that was administered. It is not known if these teachers felt this way before the workshop or if their responses were based on their workshop experiences. It is therefore recommended that a similar study with the pre- and post-self-efficacy scores of participants and a comparison group be obtained and analyzed quantitatively to see if there are any correlations between the workshop experience and their beliefs about the teaching of science.

As a result of time constraints, this study only focused on the post-workshop experience of the participating teachers. To further extend this study, it is also recommended that a pre- and post-observation of classrooms be done to compare the instructional abilities of teachers before and after the workshop. This activity could provide a more explicit representation of the degree of change in their instruction after attending the workshops.

Conclusion

This study utilized a case study approach to explore the potential value of informal science institutions such as museum and science centers. It examined the effect of the professional development programs these centers provide on the science teachers who attend them. This was achieved through the insight of six participating teachers and two instructors obtained through workshop, classroom observations, interviews and self-efficacy survey instrument.

This study adds to the literature about science education because it brings to light how the integration of museum and science center resources can enhance the instructional practices of elementary science teachers. Other researchers have noted limited effective professional development opportunities for teachers especially for science teachers who already feel inadequate to teach science because of their limited science background (Melber & Cox-Petersen, 2005). This study attempted to shed light on how informal science centers such as museums can provide the additional information science teachers need to improve their instruction. Majority of the teachers involved in this study reported that the workshop had a positive impact on their teaching practices. The extent to which the workshop experience improved their instructional practices is not known due to the small sample of participants and the duration of the study. It should be noted however that using a new sample is common in education research. As stated previously, more research is needed, however to determine how these informal science centers help teachers improve their instructional practices and positively impact student learning in science. The benefit of this study was also to draw attention of teachers to the use of workshops organized by museums and science centers to fulfill their professional development needs. It was also to recommend to elementary school teachers the need to collaborate with science centers to provide the best possible science education for their students.

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Appendix A: Teacher Interview Protocol

Science Museums and Professional Development: Teachers' Self Reflection on their Change in Practice

Introductory Remarks:

Thank you for taking the time to talk with me today. This interview will probably take about 30-60 minutes to complete. As I mentioned to you before, I am doing these interviews with some of the teachers who have participated in museum or science center professional development workshops. The information from these interviews will be pulled together and used to inform the research community, museum and science center staff of the role they play in science education. My study is not aimed at evaluating your teaching techniques or experiences. Rather, I am trying to learn more about the professional development programs museums and science centers have for teachers and how they improve the way science is taught in Elementary school.

To facilitate my note-taking, I would like to audio tape our conversations today. Please sign the release form. For your information, only the researcher in this study will be in possession of the tapes which will be eventually destroyed after they are transcribed. In addition, you must sign a form devised to meet the human subject requirements. Essentially, this document states that: (1) all information will be held confidential, (2) your participation is voluntary and you may stop at any time if you feel uncomfortable. Thank you for your agreeing to participate.

Section A. Interviewee Background Information:

Could you please tell me your name age?

How long have you been a certified teacher?

How long have you been teaching science?

What is the name of your school and school district?

How many years have you been in this district?

Which of the following best describes your teaching experience?

___________ Team teach

___________ Self-contained classroom

___________ Other (please specify)___________

Educational background

What types of teaching certificate do you hold? (Check all that apply)

___________Elementary general education

___________ Special education

What endorsements do you hold? (Please check all that apply)

__________ Early childhood

____________Elementary

____________ Middle school

____________ High school

____________ Subject area (Please list)____

Please list degree(s) and the schools from which you received them.

Degree_________________ School____

Major___________________

Section B- Museum Experience

1. Why did you attend the workshop?

2. Based on your experience at the museum what did you learn

a. professionally

b. science content

c. science methods

d. instructional methods

3. How would you describe the professional development activities in which you participated?

4. What was the most important learning or insight that you gained from the professional development?

5. How have you applied what you learned in your own classroom teaching?

6. What has been your greatest challenge in implementing the instructional strategies you've mentioned?

7. What further professional development support do you need in order to implement the instructional strategies you've mentioned?

8. What suggestions would you make to improve the professional development provided by this workshop or getting other teachers involved?

Section C- Post-Workshop Teaching

9. What post-workshop activities will you implement?

10. Do you intend to share what you have learned with colleagues?

11. Will you recommend this museum workshop with other colleagues?

12. Will you attend future workshops at the museum?

Is there anything else you would like to add that I have not asked?

Thank you for taking time to speak with me and all you have shared with me today.

Appendix B: Survey- Pre interview

Questionnaire

Please complete each answer with as much detail as possible. If the question does not apply to your situation, please indicate as such.

Teacher Beliefs: Science Teaching Self-Efficacy Belief Instrument (STEBI-A)

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

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
When a student does better in science it is often because the teacher exerted extra effort.	5	4	3	2	1
I am continually finding better ways to teach science.	5	4	3	2	1
When I try very hard, I teach science as well as I do most subjects.	5	4	3	2	1
When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	5	4	3	2	1
I know the necessary procedure to teach science concepts effectively.	5	4	3	2	1
I am effective in monitoring science experiments.	5	4	3	2	1
I generally teach science effectively.	5	4	3	2	1
The inadequacy of a student's science	5	4	3	2	1

background can be overcome by effective teaching.					
The low science achievement of students cannot be attributed to their teachers.	5	4	3	2	1
I think science concepts are important in effective Science teaching.	5	4	3	2	1
My increased effort in science teaching produces important change in my students' science achievement.	5	4	3	2	1
I am generally responsible for the achievement of students in science.	5	4	3	2	1
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	5	4	3	2	1
I find it difficult to explain to students how science experiments work.	5	4	3	2	1
I am typically able to answer students' science questions.	5	4	3	2	1
I have the necessary skills to teach science.	5	4	3	2	1
Effective science teaching has little influence on the achievement of students with low motivation.	5	4	3	2	1
Given a choice, I would not invite the principal to evaluate my science teaching.	5	4	3	2	1
When teaching science, I welcome student questions.	5	4	3	2	1
Teachers with effective teaching strategies can help students learn science.	5	4	3	2	1

Please return in the envelope provided to: Queen Ogbomo, 5380 Telluride Drive, Kalamazoo, MI 40990. For more information call (269) 544-2232 or email qogbomo@mymail.indstate.edu

Appendix C: Museum / Science Center interview Protocol

Science Museums and Professional Development: Teachers' Self Reflection on their Change in Practice

Introductory Remarks:

Thank you for taking the time to talk with me today. This interview will probably take about 30-60 minutes to complete. The information from these interviews will be pulled together and used to inform the research community about museum and science center role in science education. My study is aimed at learning more about your professional development workshop for teachers and how they improve the way science is taught in Elementary school.

To facilitate my note-taking, I would like to audio tape our conversations today. Please sign the release form. For your information, only the researcher in this study will be in possession of the tapes which will be eventually destroyed after they are transcribed. In addition, you must sign a form devised to meet the human subject requirements. Essentially, this document states that: (1) all information will be held confidential, (2) your participation is voluntary and you may stop at any time if you feel uncomfortable. Thank you for your agreeing to participate.

Section A- Demographics

1. Could you tell me about your educational background?

a. Degrees

b. Major

c. Minor

2. How long have you worked at the museum?

3. What is your position here?

4. What are your responsibilities at the museum?

Section B- Museum Professional Development.

6. When did the museum start offering professional development opportunities for teachers?

7. How is the program facilitated?

8. What are the strengths of the program?

9. What are the weaknesses of the program?

Section C- Science Teaching

10. What do you consider the best practices in science education?

11. How does the museum help teachers teach science better in their classrooms?

12. Do you have any opinion of how science should be taught in the classroom?

Section D- Collaboration.

13. Does the museum collaborate with any of the schools in the area?

14. What kinds of communication goes on between teachers and the museum?

15. Do you think the museum has any impact on the teaching of science in the classroom?

16. What can teachers learn from attending the workshop?

17. What does the museum learn from teachers?

18. What do you consider the most effective workshop experience for teachers?

19. Do the local school districts encourage their teachers to work with the museum?

Appendix D: Frequency Distribution Table

Table 5

Frequency Distribution

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
q1	6	3.00	5.00	24.00	4.0000	.89443
q2	6	4.00	5.00	27.00	4.5000	.54772
q3	6	3.00	5.00	25.00	4.1667	.75277
q4	6	4.00	5.00	26.00	4.3333	.51640
q5	6	2.00	5.00	24.00	4.0000	1.09545
q6	6	3.00	5.00	26.00	4.3333	1.03280
q7	6	4.00	5.00	27.00	4.5000	.54772
q8	6	3.00	5.00	25.00	4.1667	.75277
q9	6	1.00	4.00	14.00	2.3333	1.36626
q10	6	4.00	5.00	27.00	4.5000	.54772
q11	6	4.00	5.00	28.00	4.6667	.51640
q12	6	2.00	5.00	24.00	4.0000	1.09545
q13	6	3.00	5.00	24.00	4.0000	.63246
q14	6	1.00	4.00	11.00	1.8333	1.32916
q15	6	4.00	5.00	27.00	4.5000	.54772
q16	6	3.00	5.00	26.00	4.3333	.81650
q17	6	1.00	2.00	10.00	1.6667	.51640
q18	6	1.00	2.00	9.00	1.5000	.54772
q19	6	3.00	5.00	27.00	4.5000	.83666
q20	6	4.00	5.00	29.00	4.8333	.40825
total	6	73.00	79.00	460.00	76.6667	2.33809
means	6	3.35	4.20	23.00	3.8333	.29439