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PRE-SERVICE ELEMENTARY TEACHERS' SELF-EFFICACY BELIEFS ABOUT
SCIENCE USING THE CRITICAL INCIDENT TECHNIQUE:
A CASE STUDY APPROACH

by

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ABSTRACT

The primary goal of this case study using qualitative and quantitative methods was to investigate pre-service elementary teachers' initial self-efficacy beliefs about science and science teaching by exploring the K-12 science experiences of these prospective elementary teachers. Of the 108 participants who completed the science teaching efficacy belief survey (STEBI-B) (Enochs & Riggs, 1990), 12 participants were selected to be interviewed using Flanagan's (1954) critical incident technique. Participants were asked to share their past positive and negative incidents during their K-12 years with science and science teachers. They were also asked to report how past incidents affected them at present and how they believed they would impact them as future teachers of science in elementary schools.

The past positive and negative incidents were analyzed using Bandura's (1977) four sources of self-efficacy (mastery, vicarious, social persuasion, and physiological/emotional) and by school level; and the impact of the past science incidents on the subjects' present and future beliefs as science teachers were categorized. The results of this study revealed that pre-service elementary teachers' self-efficacy and beliefs were largely influenced by their past experiences with science in the K-12 years, and mastery experiences dominated as a source of self-efficacy. Implications for practice and recommendations for future research were made based on the findings of the study.

This dissertation is dedicated to my husband, Mr. Ravikumar Palangat,

and my children, Simmi and Parthiv, for their immense support and devotion.

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THE PROBLEM AND ITS CLARIFYING COMPONENTS

Introduction

Science education gained its importance in the United States in the early 1950s.

Since that time, various reforms have taken place in science education. Beginning in the

1990s, the Federal government initiated programs and educational objectives such as

Goals 2000 and the Educate America Act that placed new emphasis on increasing the

background knowledge of elementary teachers in science and math (President's Council

of Advisors in Science and Technology [PCAST], 2010). Despite continued efforts to

address this problem in the U.S., preparing students and developing proficient teachers in

science, technology, engineering, and mathematics (STEM) have continued to be a major

educational challenge for the nation's schools and institutions of higher education.

(PCAST, 2010). The need to encourage prospective teachers to develop inquiry skills

and motivate them to teach science at the elementary level was highlighted in the 2010

PCAST report to President Barack Obama. This, in itself, could motivate young students

to learn science and pursue science careers in the future.

Science reforms in the first decade of the 21st century have shifted the focus from

inquiry to scientific practices (National Research Council [NRC], 2012). These practices

include posing questions, exploring, analyzing, interpreting, and collecting data that are

related to understanding the nature of science and are intended to be indirectly beneficial

in developing a positive attitude of science among children (NRC, 2012). With the rapid

technological changes and science reforms, pre-service elementary teachers, therefore,

must be more responsive to new demands. They need to be role models in their enthusiasm for science, thereby producing more informed citizens in what has become a rapidly changing technological society (Watters & Ginns, 2000, p.277). Numerous researchers have emphasized the vital importance of teaching science in elementary schools and the role that elementary teachers can play in helping students to develop a liking of science and applying the knowledge of science in real life situations using an investigative approach (Conderman & Woods, 2007; Tobin, Briscoe, & Holman, 1990).

Jarett (1999, p. 49) lamented the fact that elementary science instruction was lacking in importance despite the emphasis on science reform initiatives such as No Child Left Behind and Science for All. Vaidya (1993) discussed the importance of teachers as one of the important components of education, stating:

> Every teacher is a guide, a role model in a positive way. Sometimes they are self-conscious too and this problem is reflected in the fact that many elementary teachers although competent and enthusiastic in most of the subjects they teach, simply do not enjoy science and do not feel comfortable teaching it. (p. 63)

In its 2010 report, PCAST (2010) acknowledged the gaps between present science education and the need for a better teaching force to cope with the advancements in science and technology, indicating the importance of science in the elementary grades. It is in the elementary years that children are exposed to various science activities for the first time. If teachers at the elementary level cannot positively reinforce students' interest in science, that interest will disappear. According to Enoch and Riggs (1990), science

has not typically been given priority in elementary schools; and even when it has been taught, it has not improved student achievement in science significantly.

<center>The Problem</center>

Though the importance of elementary science education has been acknowledged, there has not been a consistent approach for improving science instruction at the elementary level. Duschl (1983) observed that teachers have generally not been willing to teach science, as they are often unprepared to teach the curriculum. Tilgner (1990), in reflecting on Duschl's earlier remarks on the low quality of elementary science education, Tilgner (1990, p. 421) judged the condition of elementary science instruction to be unstable. This instability has increased the apprehension of elementary school teachers in dealing with the new science curriculum changes and the emphasis on scientific practices (NRC, 2012). Numerous researchers have expressed similar views about pre-service elementary teachers' lack of comfort and under qualification to teach science (Abell & Roth, 1992; Czernik & Shriver, 1994; Plourde, 2002; Shwarz, 2009).

Similarly, Watters and Ginns (1998), in their research on authentic and collaborative learning practices in primary science teacher education, identified that "a number of experienced teachers, along with the beginning teachers who recently completed their pre-service education have expressed their lack of confidence towards teaching science in schools" (p. 4). They also found that "many elementary teachers express a lack of confidence in their ability to teach science with dire consequences for the quality of teaching" (Watters & Ginns, 2000, p. 277). The result has often been that

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not much importance has been given to elementary science education. According to Weiss (1994), negative attitudes have revealed teachers' low levels of confidence in science and their capability for teaching science subjects.

Previous studies by Fenstermacher (1979) examining the beliefs of prospective teachers revealed that the need has been present for a long time to conduct more research in order to examine and explore the beliefs, confidence level, and attitudes of prospective teachers in teaching science and technology. Over the years, various other researchers have suggested the need to understand the intellectual and sensitive characteristics of the prospective teachers and to identify their self -efficacy towards science teaching using a qualitative approach (Feiman-Nemser & Floden, 1986; Floden & Klinzing, 1990; Pajares, 1992).

More recently, Smith (2008, p. 104) emphasized the importance of researching pre-service teachers' beliefs. Similarly, Katrina (2004) believed understanding teacher beliefs would help in gathering the personal capabilities of pre-service teachers' teaching skills. Increased attention to beliefs, confidence levels, and attitudes of prospective teachers in teaching science and technology could result in improvements that might alter and improve science educational practices (Pajeras, 1992). Clark and Lampert (1986, p. 27) expressed their view that research on pre-service teachers could provide insights that can be used to challenge students' thinking and to expand their view of the teaching profession. Kagan (1992) demonstrated in her study that pre-service teachers were comfortable with their already existing beliefs and were hesitant to change those views. Thus, there has been a need to highlight and address the issue of bringing about change in

the attitudes, confidence level, and self -efficacy beliefs of teachers early during their pre-service educational programs. This is important because pre-service teachers have come into their programs with tangible beliefs about teaching which sometimes act as barriers to their being receptive to modifying their views about teacher instruction (Richardson, 1996).

Purpose of the Study

The purpose of this research was to determine pre-service elementary teachers' self-efficacy beliefs toward teaching science based on their K-12 past experiences. Also explored was the extent to their which pre-service teachers believe that positive and negative K-12 science incidents (a) have contributed level of self-efficacy, (b) will affect them as elementary teachers, in future classrooms.

Definition of Terms

The following definitions are offered to clarify, for the purposes of this study, terminology that will be used throughout the research.

Beliefs--"judgements and evaluations that we make of ourselves, others and the world around us"(Yero, 2002, p. 21).

Incident--"any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act" (Flanagan, 1954, p. 327).

Pre-service elementary education teachers--undergraduate students enrolled in an elementary education degree program leading to certification as an elementary teacher.

Self-efficacy--"judgments of opinions of what one is capable of doing with the skills he or she possesses" (Bandura, 1997, p. 391).

Science Teaching Efficacy Belief Instrument (STEBI-B)--Enoch and Riggs' (1990) instrument used to gather quantitative data regarding pre-service teachers' initial positive and negative self-efficacy beliefs towards science teaching.

Critical Incident Technique (CIT)--Flanagan's (1954) technique which provides for a qualitative method of gathering deep rooted personal beliefs and will be used in better understanding pre-service elementary education teachers' positive and negative experiences with science and their beliefs about science teaching.

Assumptions and Delimitations, of the Study

The study was delimited to one particular group of students, those elementary education students at a large metropolitan southeastern university enrolled in SCE 3310, (Teaching Science in the Elementary School), a science education methods course, during spring 2013. The program of study which these students have completed had a core of courses that were required of all elementary education majors. These requirements ensured, to some extent, similar prior collegiate academic curricular experiences among the participants.

It was assumed that the STEBI-B, the quantitative instrument, used to collect the initial positive and negative self-efficacy beliefs towards science teaching was an

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effective instrument to elicit relevant data from the participants. Furthermore, it was assumed that participants in both phases of the study would respond truthfully to quantitative instruments and in interview settings.

It was also assumed that the critical incident technique, which provides for a qualitative method of gathering deep rooted personal beliefs, would aid in better understanding pre-service elementary education teachers' positive and negative experiences with science and their beliefs about science teaching. The critical incident technique enabled interviews with participants and required the use of probing questions to gain additional data beyond that acquired in the administration of the STEBI-B. It was anticipated that individual interviews using a structured interview technique and a broad range of questions would bring forth from participants a range of rich data and an accurate picture of how students' beliefs may have been affected by their experiences. It was also assumed that there would be a diversity of background experiences, attitudes, and levels of self-efficacy among the participants.

Significance of the Study

This research was conducted to contribute to the body of self-efficacy literature and to provide a broader picture and personal view of the experiences that affect the level of self-efficacy of pre-service teachers. This research also was intended to provide information for (a) professionals teaching at the post-secondary level who were preparing elementary teachers for 21st century schools and (b) school districts in providing professional development for elementary teachers to develop understanding about self-

efficacy, beliefs, and ways to enhance self-efficacy. This could ultimately benefit elementary students in their future elementary science teaching and potentially lead to improving students' motivation to learn and achieve in science.

<center>Conceptual Framework</center>

In science education, elementary teachers have a significant role in providing a strong science foundation and promoting positive attitudes among students. A positive self-efficacy is a central attribute elementary teachers should possess such that they have confidence in their own ability to teach science well. The conceptual framework for this study unites two key attributes--teachers' beliefs and science self-efficacy to investigate how teachers' past science experiences may have affected their current beliefs and science self-efficacy. Pre-service elementary teachers' initial self- efficacy beliefs towards science were explored using (a) the Science Teaching Efficacy Belief Instrument (STEBI-B) survey and (b) the Critical Incident Technique (CIT), both of which provided the means to investigate teachers' beliefs towards science and science teaching.

In the conceptual framework, teachers' self-efficacy and beliefs are elucidated using the STEBI-B and the CIT to provide insights on how teachers' past experiences may have affected their beliefs and science teaching self-efficacy which may, in turn, impact their future science teaching. This research is important, not only, for assisting teachers in developing a more positive self-efficacy towards science teaching, but so that they may portray a more positive attitude about science to their students. John Dewey (1909) believed that it was in the elementary years that students' attitudes were fixed

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toward science and that it was the goal of the educators to promote positive attitudes toward learning, including the learning of science. Elementary schools teachers' attitudes towards science teaching matters to their own self-efficacy and may impact the attitude of their students.

Figure 1 displays the fundamentals of the conceptual framework. Shown are pre-service elementary teachers' attitudes about science (self-efficacy) derived using the STEBI-B (Enoch & Riggs, 1990). Also shown are the prior positive and negative K-12 science education incidents that were revealed through interviews using the critical incident technique (Flanagan, 1954). Figure 1 highlights self-efficacy and the four sources and beliefs of pre-service teachers based on their past experiences with science in their K-12 years as students. This was explained using the critical incident technique in this research. The STEBI-B survey was used to elicit positive and negative beliefs about science teaching from the participants.
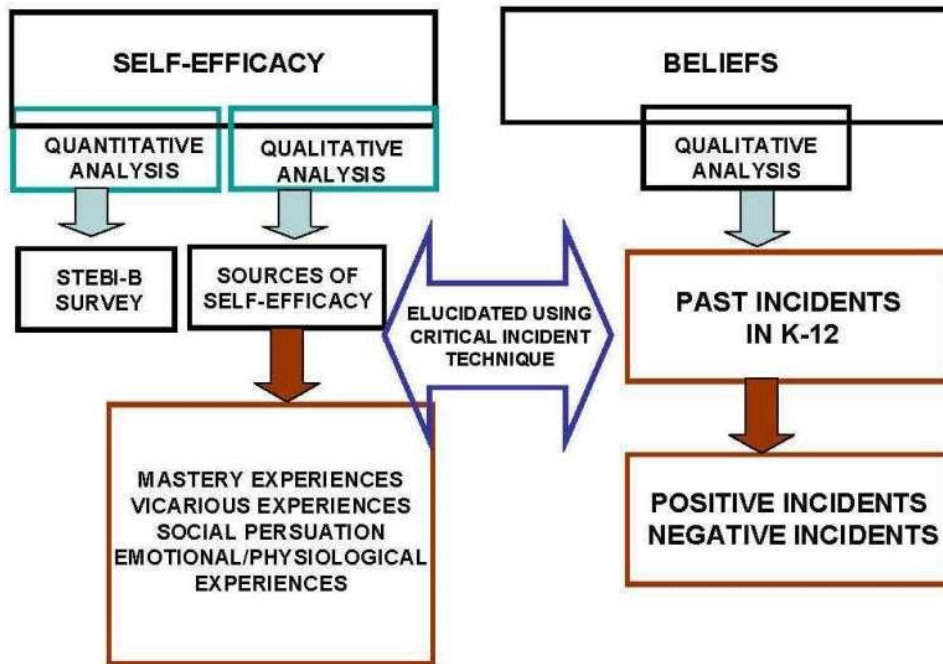
Figure 1. Graphic Display of Conceptual Framework

Teacher Beliefs

Beliefs are considered to be the best predictors of one's behavior (Bandura, 1977), specifically teacher beliefs are reflected by the strong influence on their judgments and perceptions in their classroom teaching and its overall effect on the student performance in the classrooms in which they teach (Pajares, 2002). Researchers have argued about the critical need to understand teacher beliefs to determine its influence on the quality of instruction (Kagan,1992) and to understand and analyze the effectiveness and competence that teachers will display in future classrooms (Pajeras,2002). Various events have influenced the study of teacher beliefs and their level of self-efficacy in teaching science in

elementary classrooms. In inspecting teachers' beliefs about science and science teaching, it was found that elementary schools have given low priority to science as a subject (Appleton & Kindt, 2002) as indicated by shorter periods of time being devoted to science on a daily basis (Palmer, 2001). Science has been constantly in the group of most neglected subjects in the elementary level curriculum (Silvertsen, 1993; Tilgner, 1990). For these reasons, elementary students' interest in science has been shown to decline beginning in Grade 4 (Mullis & Jenkins, 1988). This has led researchers to question what will bring about positive changes in the attitudes of children towards learning science.

In general, teachers have been perceived to be most influential in motivating and interesting students in science curricular content. Teachers' beliefs influence their own behaviors and attitudes toward various aspects of classroom teaching. It follows that the specific beliefs of beginning teachers about science teaching are based on past experiences as science students and can impact their students' interest in science. Better understanding the beliefs of these pre-service teachers may be useful in determining what future academic experiences are needed to produce teachers who can dispose a positive approach toward teaching science in elementary schools. This positive disposition towards science among beginning teachers can encourage their interest in science and other subjects through the teaching that occurs in elementary classrooms (Hallam, 2009).

Several reasons have been presented explaining pre-service teachers' beliefs and self-efficacy towards science teaching. Studies of pre-service teachers have revealed a lack of confidence in teaching science (Cobern & Loving, 2002; Jarett, 1999), lack of subject matter knowledge (Appleton, 1995); perception of science as a difficult subject

(Yilmaz-Tuzun & Topcu, 2008). If pre-service elementary teachers' beliefs and self-efficacy towards teaching science are to change, the influence of prior negative experiences with science must be negated, and they must be equipped with the required skills needed to be better informed science teachers in future classrooms. These skills would enhance positive beliefs and teacher self-efficacy in their science teaching. This, in turn, can influence their progress towards becoming superior science teachers (Newton & Newton, 2011).

Beliefs were important in this study because they influence the instructional practices of prospective teachers, and challenging their beliefs encourages them to make progress in the way they teach and learn (Abell & Lederman, 2007). This, in itself, results in a fundamental positive step in improving pre-service teachers' approaches to science teaching. On the other hand, Richardson (2003), in her research on prospective teachers' beliefs, claimed that it is difficult to change the inner beliefs of this group because they bring with them what they have experienced as students (positive or negative experiences) in their science classrooms. Based on her previous 1996 investigation into sources of beliefs, she cited schooling and instruction as the most important sources of beliefs. Teachers develop certain beliefs about subjects like science and science classroom experiences based on the way their teachers taught them science. These factors produce a strong impact on their future behaviors as science teachers. Finally investigating prospective teacher's beliefs is vital to understanding the behavior of teachers (Riggs & Enoch, 1989, p. 3). The prospective teachers' belief in their

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inability to teach science effectively leads to the behavior of pre-service teachers' avoidance of science teaching

Self Efficacy

Bandura's self-efficacy theory (1977) provided the lens to examine pre-service teachers self-efficacy beliefs. Self-efficacy was defined as "judgments of opinions of what one is capable of doing with the skills he or she possesses" (p. 391). Bandura (1986, 1997) proposed four sources of self-efficacy beliefs: (a) mastery experiences (b) vicarious experiences, (c) social persuasion, and (d) emotional/ psychological states.

Henson (2001), in her research, observed that teachers who have high levels of self-efficacy were more effective classroom teachers. Although, an abundance of research has been conducted on pre-service teachers' self-efficacy with regard to science teaching using STEBI-B, it was important to explore an in-depth understanding of the pre-service teachers' self-efficacy belief by using a critical incident technique which could provide a deeper understanding of the prospective teachers' self-efficacy beliefs towards future science teaching. Conducting interviews with pre-service teachers as part of a case study methodology provided a deeper understanding of the beliefs of this population and the extent to which events that occurred in their K-12 science education experiences have influenced their beliefs and self-efficacy levels toward teaching science.

The STEBI-B consists of two scales, a Personal Science Teaching Efficacy Belief Scale (PSTEB) and a Science Teaching Outcome Expectancy Scale (STOE), that measure the personal self-efficacy and outcome beliefs. In this study, it measured the

pre-service teachers' self-efficacy beliefs towards science and science teaching. Enoch and Riggs (1990) created the STEBI-B based on the measurements of Bandura's (1986, 1997) social learning model which assumed that people form their self-efficacy perceptions through four sources.

Sources of Self-Efficacy

According to Bandura (1997), the most important source of self-efficacy was mastery experience as it determines if a prospective teacher is ready to be successful in facing classroom instructional challenges. Mastery experiences of pre-service teachers largely depend, however, on their pre-existing knowledge in science, the various tasks accomplished in their science classes, and the degree of past support they have received as students of science from their own teachers, family, and peers. The success level of mastery experiences defines their positive self-efficacy. Failures in their mastery experiences lower their self-efficacy.

The second source of self-efficacy information is the vicarious experience. In this study, the pre-service teachers had previously had opportunities to observe their teachers performing tasks, and they were able to make comparisons among their teachers. Having role models can be a powerful influence on developing self-perceptions of competence among prospective teachers. If the prospective teachers' past experiences with their science teachers were inspiring, their belief in their own efficacy was likely to have increased. In contrast, past experiences that did not inspire may have lowered their beliefs in their own efficacy (Bandura, 1997). Pre-service teachers may also develop

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self-efficacy beliefs as a result of the verbal messages and social persuasions they receive

from others. "Positive persuasions may work to encourage and empower; negative

persuasions can work to defeat and weaken self-beliefs" (Pajeras, 2003, p. 140).

However, verbal persuasion relies on the credibility of those providing the feedback, as

well as the way in which it is "framed, structured, and delivered" (Bandura, 1997, p.

102). Anxiety and stress are also physiological conditions related to low self-efficacy for

which prospective elementary teachers must be prepared in their science classrooms

(Pajares, 2003, p. 140). More specifically, when prospective elementary teachers with

low self-efficacy are anxious about teaching science, they are more likely to try to avoid

this situation. In contrast, those whose self-efficacy is high are more likely to be

motivated and to strive to become accomplished classroom science teachers (Bandura,

1997). Earlier researchers used the STEBI-B instrument to measure participants' beliefs

about pre-service teachers' self-efficacy in science (Ramey-Gassert, Shroyer, & Staver,

1996). They found that high scores indicated positive past experiences with science and

low scores indicated lack of confidence in science due to past negative experiences.

Various researchers have also found that higher self-efficacy of pre-service teachers

towards science was accompanied by better teaching practices and that pre-service

teachers with lower self-efficacy were less likely to adhere to the science standards in

their teaching (Cavallo & Laubach, 2001; Finson, 2001; Finson, Riggs, & Jesunathadas,

1999; Rice & Roychoudhury,(2003).

Critical Incident Technique

Flanagan's (1954) critical incident technique (CIT) employs certain characteristics that can contribute to understanding pre-service teachers' self-efficacy beliefs towards science. In using CIT, researchers typically ask participants to tell them about a specific incident in this case related to their past science experiences in K-12 years, to describe any actions and behaviors of individuals most concerned who were responsible for influencing their beliefs and finally to look back on the outcome of the incident and share any further responses related to their present and future beliefs as science teachers in elementary schools (Flanagan, 1954).

This technique was used in this study because it focused on the real-life experiences of individuals and also because of its flexibility to the extent that it could be modified and adjusted to the needs of the situation (Hughes, 2007), which in this study was helpful in formulating the interview questions related to pre-service teachers' beliefs in science. This study employed the CIT five-step process that involves (a) establishing the aim of the activity, (b) establishing plans and specifications, (c) conducting interviews with participants, (d) analyzing data, and (e) interpreting and reporting the data.

This conceptual framework was used to guide the research in understanding the past science experiences of participants in their K-12 years as students' and relations with the various sources of self-efficacy. The Critical Incident Technique helped in illuminating the extent to which pre-service elementary teachers' self-efficacy levels and beliefs could be impacted so as to improve science teaching in the future. The findings of this study may be helpful to science educators at all levels in better understanding ways

in which pre-service teachers can be better prepared to meet the challenges found in elementary school classrooms.

Research Questions

This research was guided by the following questions:

1. What were pre-service elementary teachers' initial personal science teaching efficacy (PSTE) and Science teaching Outcome Efficacy (STOE) as measured in the STEBI-B survey?

2. How did pre-service elementary teachers reflect on their past positive and negative experiences as K-12 students in science, as evidenced by critical incident responses using Flanagan's (1954) critical incident technique (CIT)?

3. What sources of self-efficacy were reflected in pre-service elementary teachers' positive and negative experiences in science as K-12 students?

4. To what extent did participants believe that positive and negative incidents in K-12 science would affect them as future science teachers?

Participants

The population from which the sample for this research was drawn were undergraduate students who were elementary education majors at a large, metropolitan institution in the southeastern United States. The sample consisted of those elementary education majors who were enrolled in three sections (36 students in each of three

sections of an elementary science education methods course, SCE 3310, Teaching

Science in the Elementary School, during spring of 2013.

In Phase I of the research, 108 of the 110 enrolled pre-service teachers completed

the Science Teaching Efficacy Belief Instrument (STEBI-B). In Phase II, using the

STEBI-B results, 12 of the 108 pre-service teachers were identified, based on their

positive and negative scores on their self- efficacy beliefs toward teaching science, and

invited to participate in follow-up interviews. Participation was voluntary. Participants

were assured of anonymity and confidentiality and that their decision/involvement in the

research would not have any impact on the evaluation of their performance in their

elementary methods course.

<u>Research Design</u>

A case study research design which included mixed-methods was used in this

study. According to Creswell (2008), the use of mixed-methods research allows

qualitative data to explain and elaborate on the meaning of statistical data. This, in turn,

maximizes the strength of both qualitative and quantitative data. A mixed-methods

embedded case study design was the best method of research for this study because the

quantitative and qualitative data sources complemented each other and provided a rich

description of the cases presented. Yin (2003) indicated that quantitative and qualitative

data results in the ability to triangulate the data for a deeper understanding of the

complexity of the phenomenon studied. Thus, as supported by Johnson and

Onwuegbuzie (2004), both quantitative and qualitative data collection methods were used in a mixed-methods research paradigm to conduct this research.

Quantitative data were initially collected in Phase I of the research using the STEBI-B survey originally developed by Enoch and Riggs (1990) and revisited by Bleicher (2004). This instrument was used to understand pre-service elementary teachers' initial self-efficacy beliefs towards science and science teaching. The second phase of the study was qualitative, using an embedded case study approach. Data were gathered in interviews using the critical incident technique originally created by Flanagan (1954).

<div align="center">Instrumentation</div>

<div align="center">*Science Teaching Efficacy Belief Instrument-Pre-service (STEBI-B)*</div>

The Science Teaching Efficacy Belief Instrument-Pre-service (STEBI-B) was initially developed in 1990 by Enoch & Riggs and subsequently revisited by Bleicher in 2004. The STEBI-B is a 23-item instrument using a 5-point Likert-type scale to measure pre-service teachers' personal science teaching efficacy beliefs (PSTE). The Cronbach alpha coefficients of the two subscales of the instrument were both reported as.87 and .90 respectively. Various studies have addressed the established validity of the two subscales for use in western countries, e.g., Enoch, Scharmann, and Riggs, 1995. A copy of the instrument is included in Appendix A.

Critical Incident Technique (CIT) Interview Protocol

The critical incident technique (CIT) originally designed by Flanagan (1954) was used in conducting interviews with 12 students selected from a pool of approximately 108 pre-service teachers based on their scores on the STEBI-B. Flanagan's (1954) critical incident technique (CIT) involves a five-step process. The first step calls for establishing the aim of the activity that was, in this case, to elicit positive and negative experiences from participants. The second step requires the researcher to establish plans and specifications. To accomplish this, the researcher developed a Critical Incident Interview Protocol that was used in conducting interviews with participants. The interview protocol is included in Appendix B. The third and fourth steps of data collection were the actual conduct of interviews with participants and the analysis of data. The fifth and final step involved the interpretation and reporting of the data.

The Critical Incident Interview Protocol contains a series of questions which were asked of all interviewees in semi-structured interviews. Participants were asked to reflect on their K-12 science experiences, describe a positive incident involving a teacher, and describe the actions of all involved parties. Next, participants were asked to reflect on the experience, sharing how it affected them at the present time, and how they believed the incident may continue to affect their beliefs as a teacher. This same set of questions was repeated, but participants were asked to reflect on a negative incident.

Data Collection and Analysis

The design for multiple case study calls for collecting data from various sources for developing an in-depth understanding about the cases and also to compare the cases with each other (Baxter & Jack, 2008; Yin, 2003). In this research, quantitative data were collected using the Science Teaching Efficacy Belief Instrument-Pre-service (STEBI-B) which was administered to the approximate 110 students enrolled in three classes of SCE 3310, Teaching Science in the Elementary School.

During the first week of the February 2013 semester, the STEBI-B survey was distributed to the three classes during class time. The survey was estimated to take no more than 20 minutes to complete. Participants were asked to provide demographic information at the beginning of the survey which included their e-mail-id, and their gender. They were also informed that they might be contacted via email and asked to participate in interviews as a follow-up to the survey. This explained why their emails were being requested. Students were also assured that their participation was entirely voluntary and would not impact their performance in their class in any way.

Using the 108 completed surveys, data were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 19.0, a statistics analysis software program, to arrive at mean scores revealing the positive and negative beliefs of the respondents towards science teaching. The analysis of data obtained from this instrument permitted the identification of pre-service teachers who displayed negative and positive levels of self-efficacy beliefs towards science teaching. Of interest were the six highest scores (reflecting positive beliefs) and the six lowest scores (reflecting negative beliefs).

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Using the six highest and six lowest scores, a pool of 12 potential students was identified for possible participation in interviews in Phase II of the study. The researcher contacted students from this group via email, inviting them to participate in interviews. The intention was to select six students who reflected positive beliefs and six students who reflected negative beliefs for interview. It was these 12 selected students who were the focus of the qualitative case study which took place in the third week of February, 2013. Of the 12 participants, 10 were female, and two were male.

Qualitative data were collected using semi-structured interviews guided by an interview protocol based on Flanagan's (1954) critical incident technique. Interviews were conducted to permit the researcher to develop an understanding of participants' self-efficacy beliefs, self-confidence, and their beliefs about science and its teaching. Probing questions were also asked to get an in-depth understanding of participants' beliefs and prior experiences in their K-12 science classrooms and how those experiences impacted them in their undergraduate preparation programs and as future teachers in elementary schools.

Merriam (1998) has advocated for the analysis of qualitative data to rely on the theoretical propositions that led to the investigation. In this research, the data were organized around Bandura's (1997) four sources of self-efficacy: (a) social persuasion, (b) vicarious experiences, (c) mastery experiences, and (d) emotional/ psychological states. Questions in the interview protocol were designed to elicit data relevant to each of the four sources based on participants' past positive and negative experiences with science.

In analyzing the data, the researcher relied on the recommendations of Stake (2000). Repetitive reading, coding interview transcripts, and identifying patterns were the first steps in arriving at differences and commonalities among the cases prior to arriving at themes. This process permitted the researcher to include both the descriptive details as well as detailed analysis of themes (Stake, 2000).

Ethical Considerations

This research was initiated only after approval was received from the Institutional Review Board of the University of Central Florida (Appendix C). Participation of pre-service elementary teachers in this research was voluntary. All prospective participants were provided with a copy of the exempt consent form explaining the purpose and design of the study as well as the role played by participants in the research. Participants were assured that their names and personal details would remain confidential and anonymity would be maintained in reporting the results of the research. They were also informed that their decision to (or not to) participate would not have any impact on their activities or performance as students in the science methods course in which they were enrolled.

Summary

This chapter has provided an overview of the research that was conducted to study pre-service elementary teachers. The problem and its clarifying components have been presented including a statement of the problem, the conceptual framework, an

overview of the research design, and the methods and procedures associated with the study.

The research was focused on science related past experiences and beliefs of pre-service elementary teachers that have influenced their self-efficacy beliefs in a negative or a positive manner. The research was also concerned with examining the current levels of self-efficacy beliefs related to science teaching in pre-service elementary teachers and analyzing whether there was a relationship between teachers' previous experiences related to science and their current beliefs about science teaching based on these experiences. Finally, the research was conducted to consider how prior incidents could potentially affect them as science teachers in the future.

Chapter 2, the literature review, included relevant sub-topics to support the conceptual framework and research design. Chapter 3 provided a detailed account on the methods and procedures used to conduct the study. Chapter 4 detailed the results of the analysis of the data. Chapter 5 presented a summary and discussion of the findings along with limitations, implications, and recommendations for future research.

CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

This chapter contains a review of the literature related to the investigation of pre-service elementary teachers' beliefs and self-efficacy towards science and science teaching based on the past experiences in science as students in K-12 years. The literature review the researcher created addressed the two important component of the conceptual framework: the beliefs and self-efficacy of pre-service elementary teachers towards science and science teaching based on their past experiences with science in K-12 classrooms. To arrive at a deeper understanding of the pre-service teachers' self-efficacy beliefs, critical incidents of the per-service teachers' past experiences were identified using the critical incident technique originally created by Flanagan (1954).

First, the literature related to the beliefs of pre-service teachers and the impact of those beliefs on students preparing to be teachers is explored. Second, literature and research related to self-efficacy, particularly as it relates to the measurement of self-efficacy in pre-service elementary science teachers and the influence of sources of self-efficacy in pre-service teachers' past experiences with science is reviewed. The final section of the literature review presents the background related to the development and use of the critical incident technique in educational research and its particular relevance to this study.

To conduct this review, the researcher used several strategies in identifying literature relevant to the problem. A comprehensive library search was conducted.

Various journals related to science education, educational psychology, and qualitative methodologies served as resources. Also reviewed were books related to research in science education, beliefs and Bandura's self- efficacy theory.

<div align="center">Pre-service Teachers' Beliefs about Science and Science Teaching</div>

Two important areas of study concerning pre-service elementary teachers emerged in the literature review as important to the development of trainee teachers: (a) their beliefs about science and science teaching and (b) self-efficacy in science and science instruction. Various researchers studying pre-service elementary teacher education have recognized that students preparing to teach at the elementary level often feel unprepared to teach science. These students, primarily females, have often had past negative science experiences, contributing to their beliefs and anxieties towards science (Bryan, 2003; Hargreaves, 2000; Howes, 2002; Lee & Houseal, 2003; McGinnis et al., 2002; Zembal-Saul et al., 2000).

Beliefs play a significant role in a teacher's classroom experience. For any educational reform to be profitable, classroom teachers' beliefs should be prioritized. Based on current science reforms, many pre-service teachers who do not possess a strong science background require change in their beliefs about science and science teaching. To understand teacher beliefs, it is important to understand beliefs, in general, and their impact on science teacher education.

Teacher Beliefs Defined

Beliefs are important in pre-service elementary teacher research because they create the foundation for and often challenge teachers' instructional practices. Various researchers have attempted to define beliefs over the years; however, beliefs are subjective individual thoughts (Cobern, 2000; Southerland, Sinatra, & Matthews, 2001) that cannot be observed but can be explored based on what people say or do (Pajeras, 1992). In this study, the description of beliefs that was embraced was "attitudes, judgment, opinions, perceptions, conceptions, pre-conceptions, social strategy and repertoire of understanding" (Pajeras, 1992, p. 309). Three important sources of beliefs are mentioned in literature. Richardson (2003, p. 5), in her study on pre-service teacher beliefs, focused on three sources of beliefs: (a) personal experiences, (b) schooling and instruction, and (c) content and pedagogical knowledge. She cited the second source, schooling and instruction, as the most important because strong beliefs that already exist in the minds of prospective teachers, along with their new teaching experience in the classroom, make it almost impossible for them to change their beliefs. The entering beliefs of pre-service teachers strongly affect what and how they learn and approach teaching in classrooms.

Richardson (2003) claimed that pre-service teacher inner beliefs are difficult to change. The strong and rigid beliefs that entering teachers bring to the classroom act as "stumbling blocks" of K-12 instruction (p. 2). The researcher posited that the beliefs teacher candidates bring with them to their pre-service study have likely been affected by their own personal experience as K-12 students.

Richardson (2003) in her study on pre-service teacher beliefs, cited "schooling and instruction" (p. 3), as a most important factor, because strong beliefs that already exist in the minds of prospective teachers, along with their new teaching experience in the classroom, make it almost impossible for them to change their beliefs. The entering beliefs of pre-service teachers strongly affect what and how they learn and approach teaching in classrooms. Furthermore, in a review of the research on teachers' beliefs, Pajares (1992) cited several sources supporting the assumption that "beliefs are the best indicators of the decisions individuals make throughout their lives" (p. 307) and noted strong relationships among teachers' beliefs and their planning, instructional decisions, and classroom practices. Kagan's (1992) meta-analytic study on beliefs, supported by various researchers, asserted that teachers begin their careers with a wide range of experiences, opinions, beliefs, and conceptions of teaching and learning (Booth et al., 1998; Richardson, 1996. Holt-Reynolds (1992) commented on the value of pre-service teachers' beliefs as direct reflections of their student experiences that act as powerful checks on the strength of the inquiry-based ideas to which students are exposed. She also noted the challenge associated with influencing pre-service teachers' beliefs as a relevant goal of teacher education. In her study of nine pre-service teachers, she found that "Drawing on personal experiences of schooling, home, and community, these pre-service teachers had developed awareness about what teacher behaviors were contributing to the successes, failures, and memorable incidents in their previous histories as students" (Holt-Reynolds, 1992, p. 331).

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Impact on Pre-service Teachers' Beliefs on Science Teaching

Teachers are the most important part of education and most individuals can remember at least one teacher who made a positive impact in their lives. A teacher's impact on student behavior and knowledge is unimaginable. Several researchers have agreed that research on personal aspects of teaching knowledge has provided a wealth of information for use in personal and professional development (Bullough & Baughman 1993; Huttner, Mehlmauer-Larcher, & Reichl, 2011; Tsui, 2003). Lortie (1975) has been cited many times for his work on teacher beliefs and their impact on classroom teaching. Lortie stressed the impact of prior classroom experiences on teacher education students, stating, "The hours the teachers spend in classroom as K-12 students far outweigh their time spent in teacher education" (p. 42). He further indicated that "Teacher beliefs are difficult to alter" (p. 35) because they have been developed over long years of participation and observation of classrooms.

Similarly, Rosenthal (1991) speculated that learning to teach begins with early educational experiences in the broadest sense and with schooling. He reiterated the importance of parents and teachers' as authority figures in one's past educational experience. Rosenthal emphasized the importance of students using "reflection" and their "educational experiences" to construct an understanding of their intellectual development, philosophy of teaching, and strengths and weaknesses as teachers (p. 1). The reflective process involves students looking back at earlier experiences, engaging in a reflective interchange about situations that arise during teacher training, and projecting into the future when they will assume a fully professional role in the classroom. In a

seminal review of 40 studies published and presented between 1987 and 1991, Kagan (1992) confirmed that pre-service teachers enter teacher education programs with personal beliefs about "images of good teachers, images of themselves as teachers, and memories of themselves as students" (p. 142). Reflection has proven to be an important tool in both the preparation and professional development of teachers.

Thus, critical incidents or past experiences of teachers as students can influence future teachers in many ways. Sikes, Measor, and Woods, (1985) have been cited by numerous researchers (Darling-Hammond (2012); Day, Calderhead, & Denicolo, 2012; Huttner et al., 2011) for their work on critical incidents. Sikes et al. (1985) defined it as "key events in an individual's life around which pivotal decisions revolve which provokes an individual to take a particular decision" (p. 57). They further explained that those key events are largely responsible for an individual's decision making process.

Among the three sources of beliefs discussed in the literature reviewed, schooling and instruction were considered to be the most influential among the beliefs (Richardson,2000). Joram and Gabriele, in their 1998 study, suggested that targeting pre-service teachers' "prior beliefs in instruction" (p. 175) had a significant impact on their beliefs about learning and teaching. Lortie (1975) described teachers' prior experience as students as the "apprenticeship of observation" (p. 61) and noted that "the average student has spent 13,000 hours in direct contact with classroom teachers by the time he graduates from high school" (p. 61). Numerous researchers have supported and reiterated Lortie's statements about teacher beliefs. (Feiman-Nemser & Remillard, 1996; Mewborn

& Tyminski, 2006; Richardson, 1996; Smylie, 1988; Sutton, Watson, Parke, & Thomson, 1993).

In a study of pre-service teachers, Sutton et al. (1993) tried to understand the factors that influence pre-service teachers' interest toward science. Of the three areas identified, "past experiences with science" (p. 111) was found to be the most important factor in students' decisions to like or dislike science. Only five of the students interviewed in the study remembered anything about science from their elementary school years. Two of them enjoyed science in elementary school. One student vividly remembered a fourth-grade teacher who conducted numerous experiments that the children could repeat for their parents. The other students who recalled having science experiences in elementary school did not enjoy them. They remembered science as being taught using a textbook and worksheets. It was the perception of these students at a very early age that science was "dull and boring" (p. 111).

Earlier, Smylie (1988) in his study of pre-service teachers, concluded that "teachers' perceptions and beliefs are the most significant predictors of individual change" (p. 23). This thought was supported by Pajeras (1992), as he believed that previously developed beliefs were difficult to change. He also held the opinion that teachers' beliefs influence their perceptions and judgments, which, in turn, affect their behavior in the classroom. Various researchers, among them Nespor (1987) and Underhill (1988), have supported the view that teachers' beliefs should be examined from time to time to make classroom teaching more innovative and rewarding. Schuck (1997) reported that "teacher educators do not realize the power and the tenacity of pre-service

teachers' beliefs and attitudes. . . in a way does not sufficiently recognize, the influence of these beliefs on their learning" (p. 530).

Kagan (1992) conducted an empirical, meta-analytic study of 27 pre-service teachers examining the changes in their behavior, beliefs, or images. In her meta-analytic study she mentioned three different studies on pre-service teachers' beliefs. The first study was that of Calderhead and Robson (1991) which was focused on 12 prospective teachers as they progressed through their first year of course work in an elementary teacher education program at a British university. The results of this study revealed that students who were positive about their past experiences as students were also positive about their teaching. McDaniel (1991) studied 22 pre-service teachers (three elementary and 19 secondary) and found that the pre-service teachers tended to relate the content of their course work to their own beliefs and prior experiences in classrooms. Neither the content of the course nor the field observations conducted as part of the course affected their prior beliefs. Kagan (1992) also discussed Weinstein's 1990 study of pre-service teachers' beliefs about teaching which supported the notion that prospective teachers held optimistic beliefs about their future teaching performance. Although the contexts of these studies differed, findings were relatively similar according to Moon, Callahan, & Tomlinson, 1999. Each study documented the central role played by pre-existing beliefs and prior experience in clarifying the content of education course work. Each of these studies affirmed the strength and rigidity of "prior beliefs and images." (Kagan, 1992, p. 140).

Kagan (1992) determined that the personal beliefs of pre-service teachers about their remembrances of good teachers, the images they held of themselves as future teachers, and memories of themselves as pupils in classrooms remained unchanged during the pre-service program. She further asserted that for professional growth to occur, prior beliefs and images must be modified and reconstructed. This is necessary because student teachers approach the classroom with a critical lack of knowledge about learners. To gain this knowledge, a direct exposure to classrooms and interaction with students is essential. Various researchers have also asserted and supported the importance of studying pre-service teacher beliefs because of their influential effect on teacher preparation and understanding teachers' classroom practices and behaviors (Czerniak, Lumpe, Haney, & Beck,1999; Fang, 1996; Hart, 2002; Jordan & Stanovich, 2003; Pajares, 1992; Parker & Brindley, 2008; Walkington, 2005). Kiviet & Mji (2003) studied elementary teachers in East Africa and found that female teachers were not as prepared to teach science as their male counterparts mainly because of their cultural values and past educational experiences with science. These authors concluded that teachers needed to be supported to improve their beliefs (p. 333). A study conducted by Buaraphan (2012) in Thailand focused on pre-service teachers' beliefs toward science teaching revealed negative attitudes towards science by prospective teachers who expressed their inability to teach science well.

Various other studies of pre-service elementary teachers have been based on an assumption of relatively negative beliefs toward science and science teaching (Bhattacharya, Volk, & Lumpe, 2009; Kim &Tan, 2011; Shrigley, 1974; Tilgner, 1990;

Wenner, 1993). Whatever the position may be, there has been a consensus among researchers that improving beliefs of pre-service elementary teachers will have a valuable effect on elementary science education.

It has been consistently observed by researchers of pre-service teachers' beliefs that not much occurs in teacher education programs to alter students' beliefs. Numerous researchers, however, have indicated that pre-service teacher beliefs in science can be changed if they are directed to the right method courses (Bandura, 1997; Cakiroglu & Boone, 2002; Hart, 2002; Ho, Watkins, & Kelly, 2001; Jesky-Smith, 2002; Plourde & Alawiye, 2003; Tosun, 2000). Determining what specifically is needed in methods courses has not been without conflict. Dobey & Schafer expressed as early as 1984 that an inquiry approach to teaching science seemed inadequate. Other early researchers (Strawitz & Malone, 1986; Sunal, 1980) believed in an activity oriented approach to teaching science as the strongest predictor of interest in teaching science on the part of pre-service teachers. Rosenthal (1991), in his study of pre-service teachers, proposed the use of "the reflective strategy called critical incidents" in elementary science methods classes where students reflect on their past positive and negative science experiences and share with other students (p. 4). This approach was supported by numerous researchers who believed that a comprehensive science methods course, along with a reflective approach, would help in developing interest and positive attitudes towards science among pre-service teachers and at the same time provide opportunities to change their beliefs (Crowther & Cannon, 1998; Finson, 2001; Yesil-Dagli, Lake, & Jones (2010). Bursal (2012) found that inclusion of inquiry activities and micro-teaching experiences into

science methods courses contributed to positive changes in pre-service teachers' beliefs regarding science teaching.

On the other hand, a compilation of results from three studies conducted by Wenner in 1993, 1995, and 2001 on pre-service teachers' beliefs towards science consistently indicated that pre-service teachers aspired to help students through inquiry based questions, but they lacked confidence in their aptitude to provide answers (Wenner, 2001). He concluded his 2001 study on pre-service teachers by stating, "Science remains an academic area of low confidence among pre-service teachers" (p. 185).

The literature reviewed on pre-service teacher beliefs has revealed that beliefs are important concepts in understanding teachers' thought processes and their instructional practices. Hence, some researchers have concluded that the challenge is to reveal teachers' beliefs and to understand how these interact with the content and pedagogy of teaching (Kagan, 1992; Pajares, 1992). They have advocated that the most important way of doing this is to focus research on pre-service teachers' self-efficacy beliefs (Kagan, 1992; Pajares, 1992). Such research efforts would add value to individual teachers and would assist them in becoming more aware of their own dispositions towards teaching. This would contribute to their becoming teachers who make a positive impact in the lives of their students.

<u>Self-efficacy</u>

The concept of self-efficacy was first conceived by Bandura in 1977. In his theory, he described "self-efficacy as a judgment of one's capability of what one can do

with whatever skills they possess" (Bandura, 1986, p. 91). In social learning theory, he

mentioned two dimensions: personal self-efficacy and outcome expectancy. Personal

self-efficacy is defined as "a judgment of one's ability to organize and execute given

types of performances" (Bandura, 1997, p. 21). Outcome expectancy on the other hand,

relates to an individual's "judgment of the likely consequences such performances will

produce" (p. 21). Both of these dimensions have a powerful influence on behavior.

Hence, it can be said that higher self-efficacy leads to "greater effort, persistence, and

flexibility" during challenging events (1996, p. 544). Bandura stated his beliefs about

self-efficacy in (1995) as how people feel, think, behave, and motivate themselves.

When it comes to behaviors, self-efficacy can influence people's choice of activities.

Self-efficacy levels can increase or hamper motivation. People with high self-efficacy

approach difficult tasks as challenges and do not try to avoid them. "People's self-

efficacy beliefs determine their level of motivation, as reflected in how much effort they

will exert in an endeavor and how long they will persevere in the face of obstacles"

(Bandura, 2001, p. 10). Many researchers have supported Bandura's theory over the last

many years (Bong & Skaalvik, 2003; Frost, 2006; Greeley, 2009; Markman, Baron, &

Balkin, 2004). Several researchers have indicated that depending on these sources of

judgments, individuals have negative or positive ideas about a behavior before they

undertake it and these ideas affect their course of action (Albion, 2001; Bandura, 1986).

　　　　Self-efficacy is the motivation to perform an action if a student believes that the

intended action will result in a favorable outcome and if he or she is confident of his/her

capability to execute that action successfully (Bandura, 1977). Bandura (1977)

characterized self-efficacy as the major mediator of individual behavior and any behavioral changes that occur. Bandura has continued to develop his work over the years and defend the idea that beliefs in one's ability powerfully affect behavior, motivation, and ultimate success or failure (Bandura, 1982, 1986, 1993, 1995, 1997). Bandura's (1977, 1997) social cognitive theory essentially described self-efficacy as beliefs developed through life experiences.

Bandura's (1986) research and theories revealed various factors influencing people's self-efficacy about their capability of succeeding on particular tasks. These factors or sources of self-efficacy include (a) mastery experiences, (b) modeling, (c) verbal persuasion, and (d) psychological or emotional state. Mastery experience is developed as people get involved in different activities and tasks and interpret their earlier performances. As they do so, they tend to develop various beliefs with respect to their capabilities of performing and accomplishing successive tasks, and their actions are based on the beliefs they have developed. Vicarious experience develops when individuals are not certain about their capabilities and have less prior applicable experience. Their judgments based on self-efficacy tend to depend on their vicarious experiences. By observing other individuals performing tasks successfully, a less experienced individual can increase his/her self-efficacy beliefs. Likewise, observing others' failure can lower the level of self-efficacy in individuals (Pajares, 1996).

People also tend to develop self-efficacy beliefs due to social persuasion. This involves non-verbal and verbal judgments obtained from other individuals. Within its realistic boundaries, social persuasion helps individuals in successfully performing their

tasks where individuals are motivated to put forth extra effort in order to accomplish

certain tasks, thereby enhancing their self-efficacy. On the contrary, negative social

persuasion tends to weaken self-efficacy beliefs. The last source is the

emotional/psychological state of individuals which significantly contribute to the

formation or development of self-efficacy beliefs (Pajares, 1996).

According to Bandura (1997), people usually use a set of these sources in forming

their self-efficacy beliefs and judgments. Though research has supported these claims in

general, little is known about the specific experiences pre-service teachers have had

during their school years that foster or hinder their self-efficacy. Moreover, Bandura

(1982) defined self-efficacy as being characteristic of one's life or events in a particular

place. Hence, individual efficacy levels may vary greatly depending upon the factors of

the situation. As described by Bandura (1977), self-efficacy is a strong predictor of

behavior. According to this point of view, "Individuals have the capability of controlling

their feelings, actions, motivations, and thoughts, after self-interpreting their

performances and activities" (Pajares, Johnson, & Usher, 2007, p. 22). This helps

individuals in altering their subsequent behaviors and actions. According to Bandura

(1986, 1997), behavior can be easily predicted by individuals' beliefs regarding their

abilities and capabilities instead of what they actually are capable of doing. Therefore,

self-belief of individuals acts as a driving force for their accomplishments and

achievements.

These beliefs about self-efficacy might influence an individual in a negative or a

positive manner. Beliefs virtually touch every aspect of human life, whether related to

thinking self-deliberately, optimistically, pessimistically, or productively, no matter how well individuals are self-motivated and how well they make decisions about their lives (Bandura, 1977). For instance, after struggling and failing for years, a number of students are likely to have a weak self-efficacy level for being successful in activities or subjects they think are difficult for them (Guthrie & Davis, 2003; Linnenbrink & Pintrich, 2003; Wurst, Smarkola, & Gaffney, 2008). In other words, according to their belief, they lack the capability of succeeding in certain tasks or subjects such as mathematics, writing, or reading (Guthrie & Davis, 2003; Linnenbrink & Pintrich, 2003; Pajares, 2002; Schunk, 2001; Walker, 2003), and this belief sometimes affects their level of achievement. Students who face difficulties often resist or avoid the activities or subjects for which they have a low level of self-efficacy (Linnenbrink & Pintrich, 2002; Pintrich & Schunk, 2002; Walker, 2003). As asserted by Cunningham and Allington (2007), "No one is going to make any efforts if he or she knows that they will eventually fail" (p. 269).

In contrast, students having high levels of self-efficacy increase their accomplishments and personal well-being in various ways (Schunk, 2001). People having higher assurance and belief in their capabilities view difficult activities and tasks as challenges to be overcome rather than as threats to be avoided. As it has been summarized by Bandura (1997), students who have a higher sense of self-efficacy set higher aspirations for themselves, achieve high levels of intellectual performances, depict higher strategic flexibilities in the search for possible solutions, and are far more accurate in assessing performance quality.

Teacher Self-efficacy

Self-efficacy deals within the theoretical framework of social cognitive theory, emphasizing that people can exercise some influence over what they do (Bandura, 2006a). Skaalvik and Skaalvik (2010) referenced Bandura's 2006 work on social cognitive theory in regard to teachers and self-efficacy, stating, "Teacher self-efficacy may be conceptualized as individual teachers' beliefs in their own ability to plan, organize, and carry out activities that are required to attain given educational goals" (p. 1059). Ramey-Gassert et al. (1996) added their thoughts as follows:

> Based on Bandura's psychological construct of self-efficacy, science teaching self-efficacy has been related to teachers' belief in their ability to teach science, called personal science teaching efficacy (PSTE), and their belief in students' ability to learn, called science teaching outcome expectancy (STOE). (p. 283)

Various researchers have expressed the belief that teacher self-efficacy is integral in the education of teachers (Bandura, 1993; Dibapile, 2012; Ng, Nicholas, & Williams, 2010). Rizvi and Elliot (2005) argued that "teacher self- efficacy is an important dimension to teacher professionalism" (p. 38). Tschannen-Moran & Woolfolk Hoy (2007) summarized the importance of efficacy in the teaching profession in the following statement: "Teachers' sense of efficacy has a great impact on teachers' judgment of their capability to impact student outcomes. This has been consistently related to teacher behavior, student attitudes, and student achievement" (p. 954).

Henson (2001) mentioned in his study the historical background of teacher self-efficacy and the influence of Bandura (1977) and Rotter's (1966) concepts of teacher

self-efficacy. Based on the theoretical framework proposed by Rotter, the Rand organization first used the terminology and concept of teacher efficacy. Tschannen-Moran, Woolfolk Hoy, & Hoy (1998) defined teacher efficacy as "the extent to which a teacher believes he or she has the capacity to affect student performance" (p. 202). The second conceptual strand of self-efficacy theory grew out of Bandura's work (1977) where he defined self-efficacy "as a cognitive process in which people construct beliefs about their capabilities to perform a task at a given level of attainment" (p. 203). Bandura (1997) tried to distinguish between his concept of self-efficacy and Rotter's locus of control, differentiating the phenomenon of perceived self-efficacy and locus of control. "Perceived self-efficacy are beliefs of whether one can produce certain actions, whereas locus of control are beliefs in regard to whether actions can affect outcomes" (p. 20). Tschannen-Moran et al. (1998) interpreted Bandura's explanation as a clear indication that "perceived self-efficacy is a stronger indicator of teacher behavior as compared to locus of control" (p. 211).

Pre-service Teachers' Self-efficacy

Various researchers have confirmed Bandura's (1977) suggestion that self-efficacy is most flexible in the early pre-service teacher years (Housego, 1992; Hoy & Woolfolk, 1993; Tschannen-Moran et al., 1998). The development of research on self-efficacy beliefs of pre-service teachers has garnered a lot of interest because it has been established that self-efficacy beliefs of prospective teachers are resistant to change (Henson, 2001). According to Kelly (2000), science teacher preparation has been

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influenced by science methods courses. In turn, much of the research has focused on data collected from students enrolled in methods courses and approaches used within the course. Kelly reported that studies on pre-service teachers' self-efficacy beliefs towards science have been largely linked to the use of (a) reflection in instruction in regard to students' beliefs and experiences with science classrooms and (b) teacher knowledge of content and pedagogy. These topics are discussed in further detail in the following sections of the review.

Reflective Approach

> The reflective approach refers to the use of reflection for the personal and professional development of teachers. It emphasizes the importance of students using their educational experiences to construct an understanding of their intellectual development, philosophy of teaching, and strengths and weaknesses as teachers, and to draw on their newly constructed understanding to realize fully their potential as teachers. The reflective process involves students looking back at earlier experiences, engaging in a reflective interchange about situations that arise during teacher training, and projecting into the future when they will assume a fully professional role in the classroom. (Rosenthal 1991, p. 1)

Various researchers have introduced a reflective approach to teaching methods courses in science. Hufford (2011) used this approach to teach a biology methods course for undergraduate student teachers and found it very useful in improving pre-service teachers' teaching skills. Similarly, in an earlier study, Howitt (2007) surveyed 28 pre-service elementary teachers "to understand their belief and confidence towards science

and the teaching of science using a holistic teaching-learning approach" (p. 41). He

studied various factors affecting the confidence of the pre-service teachers and was able

to identify a number of factors such as science courses, teacher educator, pedagogical

content knowledge, learning environment, assessment and reflection. Results of his study

revealed that all the factors contributed equally to pre-service elementary teachers'

confidence, (Howitt, 2007).

In another study by Wong, Yung, Cheng, Lam, & Hodson (2008) conducted at a

university in Hong Kong, classroom videos were used to develop pre-service teachers'

conceptions of good science teaching and yielded positive results. Results from the

research on pre-service teachers by Hewitt, Pedrett, Bencze, Vaillancourt, & Yoon (2003)

suggested that a "reflective approach has the potential to help teacher candidates develop

deeper insights into their own classroom practice" (p. 483). Researchers have found

reflective practice is used at both the pre-service and in-service levels of teaching

(Griffiths & Tann, 1992; Orland-Barak, 2005). Coaching and peer involvement are two

aspects of reflective practices seen most often at the pre-service level (Ferraro, 2000).

Some earlier researchers have explored the role of the teacher educator as coach in their

study of reflective practices in teaching (Moon, Callahan, & Tomlinson, 1999; Nanjappa

& Grant, 2003; Ojanen, 1993, Reeley Freese, 1999). Ferraro (2000) further suggested

that teacher educators can most effectively coach student teachers in reflective practice

by using students' personal histories, dialogue journals, and small and large-group

discussions about their experiences. These activities help students reflect upon and

improve their teaching practices. By gaining a better understanding of their own

individual teaching styles through reflective practice, teachers can improve their effectiveness in the classroom (Ferraro, 2000). Various studies have shown that a disconnect between coursework and field experience can serve as a barrier to the development of the ability to frame a theoretical explanation of classroom practice (Beyer, 2001; Goodlad, 1990; Metcalf & Kalich, 1996; Varma & Hanuscin ,2008). Moreover, providing appropriate field experiences can be challenging in that "the desirable kinds of classrooms in which students should serve their apprenticeship quite often do not exist" (Abell, 2006, p. 77). "Pre-service elementary teachers enter their methods courses with a vision of themselves as science teachers that is closely related to their experiences as science learners" (Abell & Bryan, 1997, p. 160).

In summarizing her rationale for studying the reflective approach in teaching and learning among pre-service elementary teachers, Rosenthal (1991) discussed the positive characteristics of reflective teaching. These included (a) boosting pre-service teachers' ability to be better self-learners, (b) reducing anxiety about teaching, (c) increasing self-confidence, and (d) persevering in further studying the conflict between science as "content" and science as "process" (Rosenthal, 1991, p. 3).

Tosun's (2000) investigation of teacher self- efficacy revealed the poor and negative experiences of pre-service teachers as students in K-12 classrooms. Pre-service elementary teachers' negative attitudes and beliefs toward science and science teaching appeared to be more important than science achievement in shaping their science teaching self-efficacy. This study also revealed that the higher the self-efficacy of pre-

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service teachers, the more confident were their approaches to teaching science as compared to pre-service teachers' with low self-efficacy (Tosun, 2000).

Another investigation of elementary pre-service teachers' STEBI-B scores and Draw A Science Teacher Test-Checklist (DASTT-C) scores revealed that teachers with high self-efficacy scores were more inclined to engage in student centered teaching where students form groups doing hands-on activities than those with low self-efficacy scores. Teachers with low self-efficacy scores were associated with teacher-centered learning environments that were indoors with limited student centered activity (Yilmaz, Turkmen, Pedersen, & Huyuguzel, 2007).

Cavallo, Miller, & Saunders (2002) conducted a correlational study of 45 female pre-service teachers in a mid-western university regarding a science activity focused on the following variables: pre-service teachers' self- concept in their ability to do science, learning goals, performance goals, intrinsic and extrinsic motivation, positive effects such as pride or competence, and negative effects such as guilt or depression. Pre-service teachers' learning goal scores were positively correlated with positive effect core values and negatively correlated with negative effect experiences. It was also found that positive effect was positively correlated with increased levels of participation and that teachers would be more likely to participate in an activity if they had positive experiences. Pre-service teachers who had higher self-concepts of their ability also had more positive experiences with science activities. They found the activities to be interesting and fun and expressed interest in doing similar future activities (Cavallo et al., 2002, p. 34). This led Cavallo et al. to suggest that pre-service teachers who have

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positive science experiences may be more inclined to devote time to teaching science in their future classrooms (p. 35). Moseley, Ramsey, & Ruff (2004) suggested that content-specific school-based experiences can provide pre-service teachers with opportunities to focus on content and instructional strategies at deeper levels. Numerous researchers have supported the claim that science education courses for elementary pre-service teachers must emphasize science content, process, and pedagogy, as well as attitude (Appleton 1995; Baker, 1994; García, Sánchez, Escudero, & Llinares, S., 2003; Kelly, 2000; Lederman, Schwartz, Abd-Al-Khalich, & Bell, 2001; Nuangchalerm, 2012)

Pedagogy and Science Content Knowledge

Gustafson & Rowell (1995) expressed the belief that pre-service teachers come to their profession with many of their own ideas about science and that these are "retained as a core philosophy" (p. 600) that can aid or hinder further cognitive and affective development with respect to science. Shulman (1986) first developed "pedagogical content knowledge" (p. 9) for teacher education which he defined as "the ways of representing and formulating the subject (science) that makes it comprehensible to others" (p. 9). He strongly believed that for science teaching to be successful, both pedagogical content knowledge and subject content knowledge were equally important. Since its inception in 1986, the usefulness of pedagogical content knowledge (PCK) has become an important area of discussion for the enhancement of effective science education (NRC, 1996; NSTA, 1999).

Wenner (1993) examined pre-service teachers' science content knowledge and attitudes towards science teaching. Negative findings from the study were related to lack

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of content knowledge and lack of confidence in teaching science and the negative relationship between the two (p. 461). Two years later, in a 1995 study, Wenner found some positive results in terms of self-efficacy but saw no changes in the pre-service teachers' content knowledge of science (p. 307). He persisted in his belief that lack of content knowledge was one of the barriers to teaching self-efficacy among elementary pre-service teachers (p. 307). Five years later, Wenner (2001) continued to advocate for the importance of science content knowledge and its significance in improving the self-efficacy towards teaching of science among pre-service teachers (p. 185). Earlier research by Appleton (1999) had resulted in similar recommendations.

Various researchers have continued to study pre-service teachers' pedagogical content knowledge in recent years. In 2002, Meerah, Osman, & Halim studied student teachers' pedagogical content knowledge in physics teaching. They found that these student teachers lacked conceptual understanding of physics and were unable to use effective teaching strategies. In the same year, Van Driel, Jong, & Verloop (2002) studied 12 pre-service elementary teachers with pedagogical content knowledge as a central focus of science teaching. The results of this study revealed that "mastery experiences" (teaching experiences) and "vicarious experiences" (mentors) substantially increased pre-service teachers' pedagogical content knowledge (p. 572). In another study by Mineo, Fazio and Tarantino (2006), 28 pre-service teachers' pedagogical content knowledge was addressed in understanding a physics concept. The results of this study implied that gaining pedagogical content knowledge and subject content knowledge was accomplished in a "bidirectional process" (p. 235) where deepening of subject matter

knowledge increased the pedagogical content knowledge. Nilsson's 2008 study revealed

that "Reflection of one's work and teaching experience contributed largely to the

knowledge base of teaching and this indirectly contributed to their development of

pedagogical knowledge" (p. 1,281). Previous researchers have also suggested that

teachers' reflective abilities can improve their pedagogical content knowledge (Van Dijk

& Kattmann, 2007; Van Driel et al., 2002). In a paper presented by Beyer & Davis

(2012) on pre-service teachers' study, a criterion based approach was used to analyze

pedagogical content knowledge for science teaching and planning instruction for

students. Though the results showed weakness in their pedagogy and subject matter

especially in inquiry, over a period of time and through various mastery experiences, the

pre-service teachers made a lot of progress. A study of 70 pre-service teachers' self-

efficacy and laboratory experiences revealed a significant correlation between science

teachers' perceptions' of their self-efficacy in science teaching and science laboratory

competencies (Mihladiz, Duran, Isik, & Ozdemir, 2011;).

     Wilson, Floden, & Ferrini-Mundy (2002) reviewed 57 studies, seven of which

directly addressed the effects of subject matter preparation on science teaching. They

stated that, "The conclusions of the few studies in this area are especially provocative

because they undermine the certainty often expressed about the strong link between

college study of a subject matter and teacher quality" (p. 191). Wilson et al.'s review

also revealed that courses beyond a particular number did not affect teacher quality. In

addition, several of the reviewed studies reported a greater correlation between content

specific education courses and achievement. It was also interesting to note in this review

that although there seemed to be much concern about the lack of content knowledge of pre-service elementary teachers, there were conflicting results concerning the impact of science courses on pedagogical knowledge as it relates to student achievement (Wilson et al., 2002).

A study by Jong (2000) on prospective teachers' pedagogical content knowledge revealed the characteristics of prospective teachers' pedagogical content concerns. One of the main topics was subject matter knowledge. Of the various studies that were examined by Lederman and Guess-Newsome(1992) on subject matter knowledge and science instruction, few revealed the power of subject matter knowledge on teacher instruction. Other researchers, however, offered a contrasting view. Rodriguez (2001) was primarily concerned with cultural inequities in science education, and he found minimal evidence of these concerns on teachers' ability to teach, especially beginning teachers, and their ability to learn in diverse environments.

Cantrell et al. (2003) explored the variables affecting pre-service teachers' self-efficacy beliefs in science and found that students who had positive science experiences in high school had higher science teaching outcome expectancy (STOE) beliefs. The factors responsible were science content courses at the high school and participation in extracurricular science experiences such as science fairs. "If outcomes such as student achievement, persistence in the face of obstacles, and teacher effectiveness are indeed related to science teaching efficacy, then encouraging the development of teacher efficacy becomes important at all levels of education" (Cantrell et al., 2003, p. 189). This

was also mentioned by Tarik in his 2000 study on understanding pre-service elementary teachers' self-efficacy beliefs.

The design of various instructional strategies for pre-service teachers has contributed to the improvement of teachers' self-efficacy (Neitfield & Cao, 2003). Similarly, other researchers have also suggested the importance of instructional strategies to promote positive self-efficacy toward science and science teaching (Eslami & Fatahi, 2008; Ginns & Watters, 1996; Hall, Burley, Villeme, & Brockmeier, 1992; Haney, Lumpe, Czerniak, & Egan, 2002; Yager & Yager, 1985). Cavallo et al. (2002) summarized it well in the following statement: "By identifying variables related to these positive dispositions, science teacher educators may focus efforts on providing experiences for pre-service elementary teachers that promote greater interest and more positive attitudes toward science, which may ultimately transfer to their future students" (p. 25).

Much has been written about self-efficacy and how it pertains to elementary teachers' beliefs and actions within the classroom, including their approaches to and willingness to teach science (Britner & Finson, 2005; Czerniak & Lumpe, 1995; Eshach, 2003). Researchers' have also reported that FCAT tests have a negative impact on many students self-efficacy and motivation (Cizek & Burg, 2006; Johnson, 2007; Neilsson, 2013). According to Cantrell et al. (2003), these studies have been based on Bandura's social cognitive theory that "roots human agency in a sense of self-efficacy. . . self-efficacy beliefs motivate people toward specific actions in all aspects of their lives, and therefore have predictive value" (p. 177).

Research on the Sources of Self- efficacy Beliefs on Science Teaching

In 1992, Coladarci conducted research investigating science teaching attitudes and self-efficacy beliefs in 750 pre-service elementary teachers. The study revealed that though overall self-efficacy beliefs towards science teaching were moderate, the personal science teaching belief component was a significant indicator of the prospective teachers' beliefs toward science.

For this review, various literature was available on the quantitative studies conducted on pre-service-teachers' self efficacy beliefs and related components such as the impact on classroom management and inquiry method of teaching. However, qualitative analysis or study on these self-efficacy beliefs and its sources on science teaching was limited. Review of the literature has produced mixed results. In his discussion of self-efficacy, Bandura (1977) argued that mastery experience was a significant indicator of self -efficacy beliefs. Other researchers, however, have expressed different opinions. Tschannen-Moran and Woolfolk Hoy (2007) posited that all the sources, i.e., mastery, vicarious experiences, social persuasion, emotional/physiological experiences, in some combination, had an effect on pre-service teachers' self- efficacy beliefs toward science teaching. A study of the impact of vicarious experience on prospective teachers' self-efficacy inferred that a teacher model that was competitive, supportive and enthusiastic made a positive impression on students, thereby raising their self-efficacy beliefs (Schunk, 2001). Similarly, social persuasion, mentioned in self-efficacy literature as verbal encouragement such as "well done" and "you can do it," raised self-efficacy beliefs (Pajeras, 1992).

There are numerous references to quantitative studies measuring self-efficacy beliefs of pre-service elementary teachers' that have been noted in the literature. According to the literature reviewed, the instrument most frequently used in understanding pre-service elementary teachers' self-efficacy belief has been the STEBI-B, the instrument selected for use in this study.

Measuring Pre-Service Teachers' Self-efficacy

Ever since its inception, the STEBI-B has been considered the most reliable and valid instrument to measure pre-service teacher self-efficacy. It measures two important aspects of teacher self-efficacy: (a) personal teaching self-efficacy and (b) general science teaching outcome beliefs of pre-service teachers. Gibson and Dembo (1984) developed an instrument to measure teacher efficacy and examined the relationship between teacher efficacy and observable teacher behaviors. Factor analysis of responses from 208 elementary school teachers to a 30-item teacher efficacy scale yielded two substantial factors that corresponded to Bandura's two-factor theoretical model of self-efficacy (Gibson & Dembo, 1984, p. 569). Factor analysis confirmed the existence of two factors, personal teaching efficacy (PTE) which was assumed to reflect self-efficacy, and general teaching efficacy (GTE) which was assumed to capture outcome expectancy. Since the development of STEBI-B by Enochs and Riggs, there were no studies to re-examine its internal validity and reliability until it was revisited by Bleicher in 2004.

Various other researchers confirmed the validity of the two factors that measure pre-service teacher beliefs in science teaching (Anderson, Greene, Loewen, 1988;

Bleicher, 2004; Burley, Hall, Villeme, & Brockmeier, 1991; Hoy & Woolfolk, 1993; Sodak & Podell, 1993). Sodak and Podell (1993) used 16 items from the instrument already established by Gibson and Dembo (1984) for its higher reliability measuring pre-service teachers' self- efficacy beliefs towards teaching. Similarly, Hoy and Woolfolk (1990) further narrowed the selection of items from Gibson and Dembo's 1984 established 30-item instrument because of its changeability. The instrument included a 10-item scale, five items for personal teaching and five for general teaching efficacy. The reliability coefficient found was .77 for personal teaching efficacy and .72 for general teaching efficacy. Over the years, the 30-item questionnaire revealed inconsistencies in pre-service teacher beliefs research. This led to the development of the STEBI-B, a modified 25-item instrument designed by Enochs and Riggs in 1990.

As a result of Bleicher's 2004 review, the STEBI-B was further modified to a 23-item instrument, and its validity and reliability in pre-service teachers' self-efficacy beliefs research was further enhanced. His study on 290 pre-service elementary teachers who administered the STEBI-B at the beginning of science methods courses showed that gender, number of science courses taken, and school science experiences had significant associations with PSTE (p. 383).

Bleicher emphasized the reliability and validity of the STEBI-B which has been used in hundreds of studies to measure science teaching self-efficacy. He also assured the importance of testing the links of STEBI-B with other background variables such as gender and science courses taken (Bleicher, 2004).

In all of the previously mentioned studies, the purpose was to understand pre-service elementary teachers' self-efficacy beliefs and the impact of the four sources of self-efficacy on science teaching based on pre-service teachers' past experiences with science. The results of these studies provided valuable information about pre-service teachers' self-efficacy beliefs towards science teaching. The STEBI-B was valid for use in this continuing investigation into the self-efficacy of 108 pre-service elementary teachers in a science methods class.

To elicit pre-service teachers' self-efficacy beliefs toward science based on their past experiences as students, Flanagan's (1954) critical incident technique (CIT) was used in this study. Prior to using CIT, the literature was reviewed to determine its impact on educational research. Though few studies were identified, the reliability of this technique in understanding past incidents of an individual life and its impact on present beliefs was found to have been established. Literature related to the critical incident technique and its importance in education is described in the following section.

<center>Critical Incident Technique (CIT)</center>

The critical incident technique (CIT) has been widely used as a qualitative research tool in many areas of study, especially the service industry, medical and nursing fields, and education. CIT was first introduced by Flanagan (1954) to study social behaviors in the field of psychology. The importance of CIT in education emerged in the 1990s (Chell et al., 1991). According to Flanagan, "An incident is critical if it makes a 'significant' contribution, either positively or negatively to the general aim of the activity

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and it should be capable of being critiqued or analysed [analyzed]" (p. 3). Hughes (2007) used CIT in his study because it focused on the real-life experiences of the individuals being studied and because of its "flexibility" (Hughes, 2007, p. 3).

This study employed the critical incident technique's five-step process (Flanagan, 1954, p. 335) which included (a) establishing the general aims, (b) establishing plans and specifications, (c) collecting the data, (d) analyzing the data, and (e) interpreting and reporting the data. The research, which focused on examining the current levels of self-efficacy beliefs in pre-service elementary teachers related to science teaching, used CIT in the analysis to determine whether there was a relationship between pre-service teachers' previous experiences related to science, i.e., critical incidents, and their current beliefs about science teaching based on these experiences.

Flanagan described an "incident" as "any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act" (p. 327). He further defined it as a flexible set of principles which could be modified according to the needs of the individual being studied. Edvardsson and Roos (2001) explained this in another way, indicating that the analyses of the positive and negative incidents can be best understood in the "light of human memory mechanism and judgment process" (p. 251). In using CIT, participants focus on specific situations within a set of criteria significant to the situation. These are referred to as critical incidents. These incidents generally focus on: (a) describing a particular situation, (b) accounting for the behavior and actions of key players during the situation, and (c) reflection on the outcome or responses to the interaction or situation (Flanagan,

1954). When using CIT, Flanagan further outlined two primary principles and five

specific components to be included. These principles included a preference for the

reporting of facts according to those participating in the study versus general impressions

and reporting only those behaviors competent observers agreed contribute to the activity

under study. The components of implementation included: (a) defining the behavior to

be described, (b) determining the specific situations or incidents through which this

behavior can be generated, (c) establishing data collection processes and methods and

data analysis procedures, (d) conducting the analysis, and (e) interpreting and reporting

the data. In the CIT process, methods for collecting the data can include questionnaires

and/or interviews (individual or group). No matter which method is selected, according

to Rous and McCormick (2006), researchers should include enough contextual

information to encourage participants to recall a particular situation or instance related to

the topic of study.

CIT began to gain its popularity as an educational tool in the early 1990s, and

literature was reviewed in the present study as to the applicability of CIT in education.

The research reviewed relates to the training of medical students, nurses, adults, physical

education, and pre-service teachers.

Medical education has largely relied on CIT in understanding medical students'

journeys to medical school. Branch, Pels, Lawrence, and Arky (1993) wrote that the use

of critical incident reports in medical education was an "effective means to address

learners' most deeply held values and attitudes in the context of their professional

experiences" (p. 1,130). In the 1993 Branch et al. study, the critical incident reports were

short narratives or stories of the medical students' journeys and challenges that focused

on the events that had influenced students in pursuing the medical profession. In a

somewhat related study, Kemppainnean (2001) explored dimensions of nurse-patient

interactions and identified patients' responses to illness and health care treatment using

CIT and found it useful in identifying patients' experiences in the health care setting.

Another study, involving the Australian nursing workforce, used the same technique. It

helped in understanding the "complexities of nursing role and functions" (Schluter,

Seaton, & Chaboyer, 2008, p. 107) and the interaction between nurses and other

clinicians. In Bradbury-Jones, Sambrook, and Irvine's 2007 study, the meaning of

empowerment for nursing students was explored in relation to their clinical practice

experiences. The critical incident technique was used as a qualitative tool in

understanding three issues: "learning in practice, team membership and power"

(Bradbury-Jones et al., 2007, p. 342).

The use of CIT in teacher education has gained in popularity since the early

1990s. Various studies on pre-service teachers, adult and continuing education, and

physical education were found during the literature search. The past experiences of

student teachers and their wavering ability to think critically has been a great block for

many pre-service teachers to express the knowledge and display the skills required in an

actual classroom. Griffin (2003) studied the effectiveness of the critical incident

technique for pre-service teachers by exposing them to "field experiences with explicit

instruction to increase the capacity of pre-service teachers to develop reflective and

critical thinking skills" (p. 207). Griffin collected a total of 135 critical incidents and

analyzed them to evaluate the effectiveness of the tool to increase pre-service teachers'

levels of "reflective language and thinking, their degree of orientation toward growth and

inquiry, and modes of reflective thinking" (p. 208). This study yielded positive results in

terms of pre-service teachers' open-mindedness, responsibility, and whole-heartedness to

teach and learn (p. 207). In contrast, Tripp (1994) believed in the practicality of the use

of CIT in the teaching profession because of its unique ability to uncover "professionally

formative experiences" (p. 65). He suggested that CIT was useful in understanding the

"ongoing and discontinuous account of fragments of the past" (p. 65).

One of the important topics studied by teacher education researchers has been the

use of reflection to improve teaching and learning in classrooms. "Constructive" or

practical reflection was originally proposed by Van Manen in 1977 and discussed by

Watts, Alsop, Gould, and Walsh (2007) some 30 years later. It has been an important

approach in teacher preparation to stimulate "better classroom practices" and teaching of

science in schools (Watts et al., 2007, p. 1,025). These researchers explored the use of

pupils' questions in provoking 'critical incidents' in the professional lives of teachers (p.

1,025). Two teachers were studied using a case study approach. The intention was to

investigate the usefulness of critical incidents that led to "changes in teacher thinking" (p.

1,025) resulting in changes in classroom practice in science. Hoyles, as early as 1982,

had examined 14-year-old students' good and bad learning experiences in mathematics

by exploring "critical" events experienced by the students while learning mathematics in

schools (p. 349).

Douglas, McClelland, and Davies (2008) used CIT to study 163 undergraduate students in the UK. In their study, they encouraged the recording of situations that the students themselves perceived as critical incidents. This study encouraged a wider use of CIT in higher education research. Nott and Wellington (1995), in their study of prospective teachers, described numerous critical incidents that were used with experienced and prospective teachers in order to promote discussion and reflection on the nature of science. Francis (1997) studied critical incident reflection, examining pre-service teachers' responses to a critical incident analysis task where the focus was on the need to re-conceptualize the knowledge and the skills required to support reflection in an open inquiry (p. 169). Another powerful reflective tool in pre-service teacher research that was advocated by Wilson & Thornton (2007) was "bibliotherapy" (p. 21). Bibliotherapy was another powerful technique that was developed in psychology. Researchers have supported the importance of this curative technique for both teachers and students in elementary classrooms (Wright, 2001; Antila,2009). This technique was used in a research study involving pre-service elementary teachers who were preparing to teach emotionally disturbed students and other students with special needs (Marlowe & Maycock, 2000). It aimed to use guided reading and discussion to assist pre-service elementary teachers to respond cognitively and affectively to their own schooling. In analyzing readings about students' learning and issues such as anxiety, the subjects reflected on understanding their own school experiences. This self-reflection technique helped in providing pre-service teachers to further their understanding of their beliefs, thereby developing in them the extra enthusiasm to teach (Wilson & Thornton, 2007).

Presenting a paper at an educational conference in 1999, Mayer emphasized the need for reconstructing and revising pre-service teacher education for the new millennium. She addressed the stories of four pre-service teachers' learning processes during their elementary education program. These stories highlighted their growth as they built their teaching identities. Similarly, Bozdin and Park's 2002 study on pre-service teachers using CIT was helpful in preparing prospective teachers to be better prepared and reflect on the situations that they would encounter during their classroom teaching. The critical incidents were perceived by the pre-service teachers as relevant and meaningful for all their future practical experience with schools. There has also been growing interest in preparing physical education teachers with critical pedagogies. Curtner-Smith and Sofo (2004) conducted a study aimed at determining the influence of "critically oriented methods course and early field experiences" (p. 347) on prospective teachers' notions of the teaching learning process. The results of this study revealed that early field experience had a considerable influence on the prospective teachers (p. 347).

Pre-service teachers' biographies (Knowles & Hoefler, 1989) or personal histories (Knowles & Holt-Reynolds, 1991) elucidated the range of critical incidents which pre-service teachers recall and use to shape their emerging beliefs about appropriate classroom practices. Both Jarrett (1999) and Tosun (2000) focused on prior school science experiences as having the potential to increase teaching confidence. Tosun also argued that negative past experiences in science could be overcome by a science teaching methods course that can offer a successful or positive experience and may have the consequence of increasing confidence in future teaching. This claim was supported by

other researchers whose findings were similar in related areas such as cooperative

learning (Scharmann & Orth Hampton, 1995, p. 126) and learning cycles (Settlage, 2000,

p. 43). Angelides (2001) advocated for CIT as a speedy method to collect and analyze

data qualitatively, especially in teacher education, justifying this view because of pre-

service teachers' participation and contribution to the understanding and usefulness of

classroom teaching and learning. Butterfield, Borgen, Amundson, and Maglio (2005)

similarly supported the continuing promise of the critical incident technique in their

statement that "the future of the CIT is promising and full of possibilities, and we look

forward to its continued growth over the next 50 years" (p. 497).

<u>Summary</u>

Three important elements of the conceptual framework have been addressed in

this literature review. First, the literature related to the beliefs of pre-service teachers and

the impact of those beliefs on students preparing to become teachers was explored.

Second literature on research related to self-efficacy and sources on pre-service

elementary teachers, particularly as it concerns the measurement of self-efficacy in pre-

service elementary science teachers, was reviewed. The final section of the literature

review was focused on the development and use of the critical incident technique in

educational research and its particular relevance to this study. Chapter 3 provided a

detailed account of the methods and procedures used to conduct the study. Chapter 4

detailed the results of the analysis of the data, and Chapter 5 presented a summary and

discussion of the findings along with implications and recommendations.

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CHAPTER 3
METHODOLOGY

Introduction

This chapter was focused on the methods and procedures used to conduct the

study. The purpose of the study, the research questions, the research design,

instrumentation, population, and sample are presented. Data collection and analysis

procedures, along with ethical considerations, are also discussed.

Purpose of the Study

The purpose of this research was to determine pre-service elementary teachers'

attitudes toward teaching science based on their K-12 past experiences. Also explored

was the extent to which pre-service teachers believe that positive and negative K-12

science incidents have contributed to their level of self-efficacy and will affect them as

elementary teachers, in future classrooms.

Research Questions

Four research questions were used to guide the study. They were:

1. What were pre-service elementary teachers' initial personal science teaching

   efficacy (PSTE) and science teaching outcome efficacy (STOE) beliefs as

   measured in the STEBI-B survey?

2. How did pre-service elementary teachers reflect on their past positive and negative experiences as K-12 students in science, as evidenced by critical incident responses using Flanagan's (1954) critical incident technique (CIT)?

3. What sources of self-efficacy were reflected in pre-service elementary teachers' positive and negative experiences in science as K-12 students?

4. To what extent did participants believe that positive and negative incidents in K-12 science would affect them as science teachers?

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

The study was conducted using a case study design which included the collection of quantitative and qualitative data. According to Yin (2003), "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context when boundaries between the phenomenon and context are not evident" (p. 13). It is a useful method, especially when one wants to explore the experiences from the past believing that they might be highly significant to the research study, in "recollecting the real life events" (p. 2). He also emphasized that "evidence from multiple cases is often considered more compelling and the overall study is therefore regarded as being more robust" (p. 46).

A case study approach was, therefore, appropriate for this research because of the interest in the past science experiences of pre-service teachers. Yin (2003) also advocated the use of case studies when researchers wish to delve into issues by asking "Why?" and "How?" but have little control over the incidents in the research (Yin, 2003,

p. 2). Based on the research questions in this study which were structured around pre-service teachers' self- efficacy beliefs, this case study could, according to Yin, be "an exploratory or descriptive case study" (p. 1).

Case study methods have been criticized as lacking precision. Yin (2003) expressed the belief that case studies can be reduced to "theoretical propositions" as they do not necessarily represent a sample (p. 10). This is applicable to this study in that the goal was to explore a social phenomenon with respect to pre-service elementary education teachers' past science experiences.

Gay and Airasian (2003) argued that the main purpose of a case study approach is to identify various factors and to determine if there is any relationship between those factors. Also of interest, according to Gay, is whether the factors have contributed to the current behavior of subjects in a study. In other words, "The purpose of a case study is to determine why, not just what" (p. 207). In this study, students who represented a variety of attitudes and confidence levels with regard to science and science teaching were the cases of interest.

In Phase I of the research, quantitative data were gathered to measure levels of self-efficacy and beliefs of pre-service elementary teachers enrolled in a science methods course in spring 2013 at the target university. To accomplish this, the Science Teaching Efficacy Belief Instrument (STEBI-B) (Enoch & Riggs, 1990) was administered to all participants.

Phase II of the research was qualitative in nature, and Flanagan's (1954) critical incident technique (CIT) was used to gather data from participants. The researcher

employed a multiple case study approach (Yin, 2003) in describing the negative and positive K-12 science experiences of the pre-service elementary teachers selected to participate in interviews. The researcher strived to understand how individuals constructed meaning about their previous experiences with respect to science and science teaching by depending upon their personal views and words (Creswell, 2002). Data were triangulated by connecting the positive and negative scores derived from the STEBI-B instrument, the positive and negative experiences with science using the critical incident technique and the four sources of self-efficacy as proposed by Bandura (1997) to allow for an in-depth, rich, and descriptive collection of data.

Population and Sample

The population from which the sample for this research was drawn was comprised of undergraduate students who were elementary education majors at a large, metropolitan, institution in the southeastern United States. The sample consisted of 110 elementary education majors who were enrolled in three sections (37 students in two sections and 36 in one section) of an elementary science education methods course, SCE 3310, Teaching Science in the Elementary School, during the 2013 spring term. SCE 3310 emphasizes teaching science through inquiry by integrating pedagogical and content knowledge.

Science Teaching Efficacy Belief Instrument-Pre-service (STEBI-B)

The Science Teaching Efficacy Belief Instrument-Pre-service (STEBI-B) is a 23-item instrument using a 5-point Likert-type scale to measure pre-service teachers' personal science teaching efficacy beliefs (PSTE). It was initially developed in 1990 by Enoch & Riggs and subsequently revisited by Bleicher in 2004.

This survey instrument was based on Bandura's theory of self- efficacy which was a two component model comprised of (a) personal science teaching efficacy (PSTE) and (b) science teaching outcome efficacy (STOE) beliefs. Personal science teaching efficacy was derived through 13 items (2, 3, 5, 6, 8, 12, 17, 18, 19, 20, 21, 22, 23). Of the 13 items, five are positively worded and eight are negatively worded. The STOE consists of 10 items (1, 4, 7, 9, 10, 11, 13, 14, 15, 16). Responses to all questions are measured using a Likert-type scale of 1-5 where 5 = strongly agree, 4 = agree, 3 = uncertain, 2 = disagree, and 1 = strongly disagree. The negatively worded items on the PSTE sub-group are reverse graded. The entire instrument was administered in this study. PSTE scores ranged from 13 to 65 and STOE scores ranged from 10 to 50.

Reliability and Validity of the Instrument

The data collected from the 108 participating elementary education pre-service teachers enrolled in SCE 3310, Teaching Science in the Elementary School, via the STEBI-B survey were analyzed using SPSS version 19 software to obtain a descriptive analysis of the 23 items. These data were used in validating the instrument. Descriptive

statistics were run on SPSS to compare the means and standard deviations of previous

studies with those of the present study. The item means and standard deviations of the

subgroups were similar to those found by Enoch and Riggs (1990) and Bleicher (2004).

The comparable descriptive statistics of three studies are presented in Table 1.

Additionally, a factor analysis was performed on two factors (PSTE and STOE) using

Enoch and Riggs' (1990) procedure. An oblique rotation with Kaiser normalization was

used to compare the results in this study to the results in the original studies of Enoch and

Riggs (1990) and Bleicher (2004). A reliability scale test was also conducted to

determine the Cronbach's alpha for this study and compare it to those of previous studies.

The principal components model of factor analysis was employed.

Table 1

Comparative Descriptive Statistics: 2013, 2004, and 1990

Item	Ravikumar (2013) Mean	Ravikumar (2013) Standard Deviation	Bleicher (2004) Mean	Bleicher (2004) Standard Deviation	Enoch & Riggs (1990) Mean	Enoch & Riggs (1990) Standard Deviation
1	3.852	.7832	3.77	.97	3.79	.87
2	4.630	.5569	4.48	.57	4.26	.67
3	4.009	.7913	3.78	.98	3.66	1.06
4	4.222	.6165	4.16	.70	4.22	.66
5	3.565	.7767	2.33	.86	2.72	.90
6	4.426	.6442	3.82	.81	3.81	.84
7	3.852	.5930	3.31	1.01	3.34	.96
8	4.556	.5354	4.14	.74	4.12	.73
9	4.194	.5375	4.14	.74	3.92	.82
10	3.639	.7293	2.76	.92	2.83	.95
11	3.917	.5821	3.68	.85	3.77	.80
12	3.889	.7405	2.88	.96	3.48	.90
13	3.787	.8433	3.43	.99	3.40	1.03
14	3.769	.6500	3.63	.84	3.50	.78
15	3.741	.7534	3.62	.91	3.55	.86
16	3.843	.7873	3.71	.84	3.86	.72
17	3.972	.7164	3.49	.84	3.57	.91
18	3.972	.5874	3.39	.84	3.46	.80
19	3.380	1.0913	2.87	1.06	2.96	1.13
20	3.759	.9260	3.47	.96	3.41	1.05
21	4.009	.7794	3.78	.84	3.81	.77
22	4.528	.6031	4.37	.70	4.32	.68
23	4.037	.9061	3.26	1.02	3.43	1.00

The 23 items were loaded on two components. The results are displayed in

Tables 2 and 3. Table 2 contains the personal science teaching efficacy (PSTE) factor

loadings for the 13 PSTE items. Most of the PSTE items loaded on factor 1 were above

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.4. However, two items, 5 and 12, loaded above .5. Items 5 and 12 state "I know the steps necessary to teach science concepts effectively," and "I understand science concepts well enough to be effective in teaching elementary science." These items may have had loading problems because most of the participants were enrolled in their first science methods course and had not yet learned the skills necessary to teach science effectively.

Table 3 contains the factor loadings for the 10 items relating to science teaching outcome efficacy (STOE), most of which loaded on component 2 at .4 or above. STOE item 9, "The inadequacy of a student's science background can be overcome by good teaching," loaded on factors 1 (.15) and 2 (.24), both of which were below the cut off value of .32 suggested by Stevens 1996). Item 13 also demonstrated low values in this study. These low values were similar to those found in the original studies by Enoch & Riggs (1990) and Bleicher 2004. These low values were considered "questionable" because they were below the minimum .32 (Bleicher, 2004, p. 386).

The comparison of the factor loadings revealed close to similar loadings, with the two factors accounting for 22.17% of the variance with eigenvalues of 5.09 and 2.03 for PSTE and STOE, respectively, for the present study. This was comparable to 36.38% of variance and eigenvalues of 5.30 and 3.14 respectively for PSTE and STOE in Bleicher's study (2004).

Table 2

Factor Loadings: Personal Science Teaching Efficacy (PSTE)

Item	Enochs &Riggs (1990)		Bleicher(2004)		Ravikumar (2013)	
	Factor 1	Factor 2	Factor 2	Factor 1	Factor 1	Factor 2
2	.44	.19	.27	.41	.47	.24
3	.54	-.03	.06	.62	.69	-.06
5	.52	.05	.06	.38	.51	.03
6	.65	.24	-.04	.61	.63	.02
8	.59	.07	-.01	.59	.74	.01
12	.51	.16	.03	.62	.52	.10
17	.73	-.11	.03	.77	.81	-.07
18	.62	-.10	.09	.77	.57	.03
19	.50	.-02	.13	.66	.73	-.03
20	.64	-.03	.07	.72	.70	-.10
21	.60	.25	.04	.75	.62	.04
22	.55	-.20	.19	.49	.50	.05
23	.64	-.02	.11	.66	.72	-. 03

Table 3

Factor Loadings: Science Teaching Outcome Efficacy (STOE)

Item	Ravikumar (2013)		Bleicher (2004)		Enoch & Riggs (1990)	
	Factor 1	Factor2	Factor1	Factor 2	Factor1	Factor 2
1	-.12	.57	.08	.58	.09	.47
4	-.02	.64	.11	.69	-.08	.45
7	.12	.43	-.25	.66	.05	.47
9	.15	.24	.17	.38	-.02	.39
10	.14	.44	-.05	.31	.22	.33
11	-.04	.40	-.02	.52	.09	.51
13	.29	.14	.10	.13	.14	.22
14	.02	.54	.11	.63	-.05	.65
15	.13	.61	.10	.73	-.04	.76
16	.21	.50	.07	.63	-.02	.53

These results indicated the instrument was valid for use in determining pre-service elementary teachers' personal science teaching beliefs. However, the science teaching outcome efficacy subscale was weak, especially when items 9 and 13 were considered. The reliability on the STOE factor increased from .63 to .65 for this study when items 9 and 13 were removed. The low validity of the STOE factor may have occurred because these undergraduate students had not yet been exposed to classroom teaching. Table 4 displays the comparative reliability of the STEBI-B. The present data set produced a Cronbach's alpha of .84.8 for factor 1 (PTSE) which was comparable to the alpha reported in both previous validation studies.

Table 4

Reliability of the STEBI-B Survey

Descriptor	Enochs & Riggs (1990)	Bleicher (2004)	Ravikumar (2013)
Population (N)	217	290	108
Cronbach's alpha			
Personal science teaching efficacy (PSTE)	.90	.87	.85
Science teaching outcome efficacy (STOE)	.76	.72	.63

Critical Incident Technique

The critical incident technique (CIT) is a method first introduced by Flanagan (1954) for use in the study of social behaviors in the field of psychology. Flanagan defined an "incident" as "any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act" (p. 327). Critical "incidents" were used by Flanagan to understand the behaviors of individuals that contributed to their success or failure in a specific situation. According to Flanagan (1954), "An incident is critical if it makes a 'significant' contribution, either positively or negatively, to the general aim of the activity, and it should be capable of being critiqued or analyzed" (p. 338).

CIT is a flexible technique that has been used in various contexts, has undergone continuous development and refinement over a period of 60 years, and has been widely used in education since the 1990s (Chell 1998). In the 1970s, the methodology was tested for use in adult and continuing education (Oaklief, 1976). Bodzin and Park (2002) used CIT in studying reflections of pre-service teachers and their interaction using telecommunication networks.

In this study, CIT was used to conduct interviews with selected pre-service teachers regarding their prior K-12 educational science experiences. The technique enabled the exploration of positive and negative incidents in students' prior K-12 educational science experiences. The incidents and beliefs revealed in the interviews were analyzed using the four sources of self-efficacy: (a) mastery experiences, (b) vicarious experiences, (c) physiological/emotional experiences, and (d) social persuasion.

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The Critical Incident Technique Interview Protocol used to guide the interviews is displayed in Appendix B.

The assertions presented were based on the original patterns and themes that emerged from the data. To arrive at the themes, the researcher revisited the data, rereading the transcripts of interviews several times before identifying the themes and formulating related assertions. This process resulted in a reliable process for accurately identifying themes reported in this study to support assertions.

<u>Data Collection</u>

Phase I

In Phase I of the research, the 23 item STEBI-B survey by (Enoch & Riggs, 1990) was administered to 110 undergraduate elementary education students enrolled in a science methods course, SCE 3310, Teaching Science in the Elementary School, during the spring of 2013. Three sections of SCE3310 were offered for undergraduate elementary education students during the spring semester 2013, enrolling 36 in one section and 37 in each of two sections. The researcher personally administered the instrument to undergraduate elementary education students during the first 30 minutes of a regular class period of an elementary science methods class with the permission of their professors. After introducing herself, the researcher explained the purpose of the survey and the contribution that students would be making to her research. Participants were assured that their participation was voluntary and that all information shared with the

researcher would remain confidential. Students were also made aware of the Institutional

Research Board (IRB) guidelines, and a copy of the exempt research status received from

the IRB (Appendix C) was attached to the survey for students' reference. Participants

were also informed that a number of randomly selected students would be contacted via

email and requested to participate in interviews during Phase II of the research.

Data collected from the administration of the STEBI-B were used in selecting

students for the second phase (interviews) of the study. Students' responses from the

survey were tabulated in Excel® and analyzed using SPSS® software as outlined in

Enochs and Riggs (1990). The combined science teaching outcome efficacy (STOE) and

personal science teaching efficacy (PSTE) scores were totaled, and these data were

analyzed to identify students with the highest negative and highest positive self-efficacy

beliefs with regard to science and science teaching.

A total of 12 pre-service elementary teachers were purposely selected for further

participation in Phase II of the research. One variance occurred in the selection process

which called for identifying the six highest positive scores and the six lowest negative

scores on the STEBI-B. In order to ensure male representation in the sample, the six

highest positive scores and six lowest negative scores on the STEBI-B for females were

identified; and the highest positive and lowest negative male scores were also identified.

Thus, of the 12 undergraduate students selected for interview, 10 were females and two

were males. This group was representative of the research study participants.

The researcher contacted the prospective interviewees via email (Appendix D)

inviting them to participate and requesting that they respond by return email. All 12

participants agreed to participate in interviews. Scheduling of the interviews was completed via email, and all of the interviews were able to be scheduled between February 18 and 22, 2013. Table 5 displays the interview participants and the dates and times of each of the interviews.

Table 5

Schedule of Phase II Interviews With Pre-service Elementary Teachers

Interview Participants	Date	Time
TW	February 19, 2013	9:00 am
HR	February 19, 2013	9:30 am
AW	February 19, 2013	10:00 am
EG	February 19, 2013	1:00 pm
BR	February 20, 2013	11:30 am
BA	February 20, 2013	12:00 pm
TB	February 20, 2013	12:30 pm
JN	February 21, 2013	9:00 am
VB	February 21, 2013	9:30 am
NV	February 21, 2013	10:00 am
MK	February 22, 2013	10:00 am
AS	February 22, 2013	10:30 am

Phase II

In Phase II of the research, interviews were conducted with 12 undergraduate elementary education students enrolled in a science methods course, SCE 3310, Teaching Elementary Science in Schools. Participants were interviewed in an early week of the spring semester course in order to probe their self-beliefs toward science and science teaching prior to their exposure to experiences in the methods course. The group

consisted of 10 females and two males who, of 108 students who completed the survey, scored highest and lowest on the STEBI-B survey.

With the assistance of the Graduate Studies Coordinator, it was arranged for all interviews to be conducted in Education 115, a conference room in the education complex. The participants were prompt in appearing for their interviews. The researcher began each interview by introducing herself and thanking the student for agreeing to participate in an interview. The researcher then explained the purpose of the interview and reassured participants that their conversations would remain confidential, and their names would not be revealed. She also informed each participant that with permission, the interview would be audio recorded. All interviewees agreed to have their interviews recorded. This was accomplished using Audacity, a free online software. The recordings were subsequently transcribed by a graduate assistant in the College of Education within a week after the interviews were completed.

Semi-structured interviews lasting approximately 30 minutes each were conducted with each of the participants. According to Merriam (2009), in a semi-structured interview,

1. The interview guide is a mix of more or less structured questions.

2. All questions are flexible.

3. Usually specific data is required from all participants.

4. Largest part of the interview is gathered by a list of questions or issues to be explored. (p. 89)

The Critical Incident Technique Interview Protocol (Appendix C) developed by the researcher was used to guide the interviews. The protocol was based on the critical incident technique created by Flanagan (1954). Interviewees were encouraged to feel comfortable and to "talk freely about their points of view" (Bogdan & Biklen, 1992, p. 97). Interviews were focused on background information with a goal of gathering a detailed account of interviewees' prior K-12 science experiences as students.

The researcher initiated conversation with the interviewees by asking them to share information regarding their background and current status as students. This conversation was designed to put the interviewees at ease prior to posing the actual interview questions.

Interviewees were asked to reflect on their K-12 science experiences and to describe an incident or experience involving a science teacher or a science activity that occurred that most affected their beliefs about science in a positive way. The researcher then encouraged them to talk freely about the incident, i.e., what they thought, said, did in response, and in what grade this occurred. Interviewees were then asked two further questions: (a) how the experience affected them at the present time and (b) how they believed the experience would continue to affect their beliefs in themselves as future teachers. Each individual interview lasted for 30 minutes.

Data Analysis

The conceptual framework for this study merged two elements, teachers' beliefs and science self-efficacy, to investigate how pre-service teachers' past science

experiences may have affected their current beliefs and science self-efficacy. This was also of interest in order to gain insights on how pre-service teachers' past experiences may impact their future science teaching.

Pre-service elementary teachers' personal science teaching efficacy (PSTE) and science teaching outcome efficacy (STOE) beliefs were used to investigate teachers' initial science self-efficacy. Students' responses from the STEBI-B survey were tabulated in Excel® and analyzed using SPSS® software as outlined in Enochs and Riggs (1990). The PSTE statements included questions related to personal confidence of the pre-service teachers' ability to teach science, whereas the STOE questions were related to pre-service teachers' beliefs that certain methods of teaching could affect the outcome of student learning. One PSTE item, to which participants were asked to respond, was, "I know the steps necessary to teach science." A typical STOE item called for participants to respond to the following: "Students achievement in science is directly related to teacher effectiveness in science teaching." The entire STEBI-B survey is displayed in Appendix A.

The combined science teaching outcome efficacy (STOE) and personal science teaching efficacy (PSTE) scores were totaled, and these data were analyzed to identify students with the highest negative and highest positive self-efficacy beliefs with regard to science and science teaching. For Phase 1 of the study, data collected from the 23-item STEBI-B survey were analyzed to select the pool of students for the qualitative study . The answers to the items in STEBI-B were coded using a Likert-type scale of 1 to 5 where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

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Some of the items which were negatively worded were reverse coded as follows: 1 = strongly agree, 2 = agree, 3 = uncertain, 4 = disagree, and 5 = strongly disagree.

Items on this instrument were based on Bandura's two-component model of self-efficacy. Bandura (1977, 1997) divided the two components into personal science teaching efficacy (PSTE) and science teaching outcome efficacy (STOE). Of the 23 items in this survey, 13 items (2, 3, 5, 6, 8, 12, 17, 18, 19, 20, 21, 22, and 23) were PSTE items. The remaining 10 items (1, 4, 7, 9, 10, 11, 13, 14, 15, 16) were STOE items.

The values of the 13 items in the PSTE factor were added to produce an overall PSTE score for each individual with a possible range of 13 to 65. The values of the 10 items in the STOE factor were computed to produce an overall STOE for each participant with a possible range of 10 to 50. These scores were computed using Microsoft excel. Descriptive analysis of the total PSTE and STOE scores of all participants were analyzed using SPSS to determine the mean and standard deviation, and establish the normality of the two factors. All statistical analyses were performed using SPSS v.19.

The participants in this population were coded numerically from 1 to 110. The survey was administered to 110 participants, 108 of whom provided sufficiently complete responses to the survey to be included in the population. From the 108 survey responses, six participants with the highest and lowest PSTE and STOE combined scores were selected for their positive self-efficacy beliefs in science teaching and six participants with the lowest overall scores were selected based on their negative beliefs in science teaching. These 12 selected participants with highest and lowest scores on the STEBI-B

survey were interviewed for Phase II of the study which was conducted using a qualitative case study approach.

In Phase II, interviews were conducted with the 12 selected pre-service elementary teachers who were asked to reflect on their critical incidents (CI), past positive and negative experiences, as K-12 students in science. The interviews were conducted using an interview guide, the Critical Incident Technique Interview Protocol, developed by the researcher and based on Flanagan's (1954) critical incident technique. The interviews were recorded and transcribed verbatim, reviewed, and coded to identify past positive experiences (PE) and negative experiences (NE).

Also important to this research were the sources of self-efficacy that were reflected in pre-service elementary teachers' positive and negative experiences in science as K-12 students. The past positive and negative experiences of pre-service elementary teachers with science were used to identify sources of self-efficacy. Bandura's four sources of self-efficacy served as a guide to examine teachers' experiences for these sources: (a) mastery experience (ME), (b) vicarious experience (VE), (c) social persuasion (SP), and (d) physiological/emotional experience (P/E). Mastery experience in this research was related to the pre-service teachers' past success or failure in performing science related tasks which included hands on activity. Vicarious experience (VE) was coded for pre-service elementary teachers' admiration for their K-12 teachers who were their role models in science and who made a positive difference in their attitudes towards science teaching. Social persuasion (SP) was analyzed based on how the pre-service elementary teachers expressed their potential influence by their teachers'

encouraging words such as "Very good" and "Keep up the good work" which persuaded them to do better work in science. A verbal discouragement from teacher or any other individual in their past experience with science in K-12 could have been a negative influence on the pre-service elementary teachers' self- efficacy beliefs toward science. Physiological/emotional experience of the pre-service elementary teachers' self-efficacy beliefs towards science in their K-12 years was analyzed based on how interviewees emotionally reacted to their past negative experiences and how their performance was impacted as a student in science classrooms.

The researcher sought to identify the extent to which participants believed that positive and negative incidents in K-12 science would affect them as science teachers. This was accomplished by careful examination of the interviewees' responses related to their K-12 experiences for evidence of positive and negative incidents that may continue to affect them in their future roles as science teachers. Such incidents were coded as Impact (I).

Ethical considerations

Kvale's (1996) ethical guidelines for conducting interviews were used to guide the interview process in the study. According to Kvale (1996), "Professional ethical codes serve as a context for reflection on the specific ethical decisions throughout the interview inquiry" (p. 25). Kvale has expressed the belief that ethical guidelines in social science research concerns three areas: (a) confidentiality, (b) informed consent of subjects, and (c) knowledge of consequences of participation (p. 26).

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The participation of the pre-service teachers in this study was voluntary, and all participants were aware that they could withdraw at any point of time without penalty. Although adult consent forms are usually signed in qualitative studies, this research was exempted from regulation with the permission of the Institutional Review Board of the University of Central Florida. Participants were provided with a copy of the exempt letter from the IRB indicating consent signature of participants was not required. All information was treated as confidential and safeguarded with concern for participants' identities. The names of the subjects were not revealed, and pseudonyms were used to identify the subjects. The only individuals who had the access to the interview tapes and transcriptions were the researcher, the transcriptionist, and the chair of the dissertation committee.

<u>Summary</u>

This chapter has addressed the methods and procedures used to conduct the study. Included were the research design, the population and sample, the setting of the study, and the instrumentation used to gather qualitative and quantitative data in the research. The data collection and analyses procedures have been detailed, and ethical considerations have been discussed. The findings of this study are presented in Chapter 4.

CHAPTER 4
DATA ANALYSIS

Introduction

The purpose of this study was to explore the initial self- efficacy beliefs of the

pre-service elementary teachers towards science teaching using Flanagan's (1954) critical

incident technique. The conceptual framework for this study combined two elements -

teachers' beliefs and science self-efficacy to investigate how teachers' past science

experiences may have affected their current beliefs and science self-efficacy. The pre-

service elementary teachers' initial self- efficacy beliefs toward science were explored

using the Science Teaching Efficacy Belief Instrument (STEBI-B) survey and Flanagan's

critical incident technique (CIT).

This study was guided by four research questions that determined pre-service

elementary teachers' attitudes toward teaching science based on their K-12 past

experiences. Also explored was the extent to which pre-service teachers believed that

positive and negative K-12 science incidents (a) contributed to their level of self-efficacy,

b) may affect them as elementary teachers in future. The participants in this research

were 110 pre-service elementary teachers enrolled in three sections of SCE 3310, a

science methods course.

The data analysis was guided by the research questions. Research Question 1 was

answered using quantitative data and analyzed using Microsoft excel and SPSS v19.

Research Questions 2, 3, and 4 were answered using qualitative analysis focused on

responses of purposefully selected participants. Flanagan's (1954) critical incident technique was used to elicit participants' responses to interview questions.

<u>Data Analysis for Research Question 1</u>

What were pre-service elementary teachers' initial personal science teaching efficacy (PSTE) and science teaching outcome efficacy (STOE) scores as measured in the STEBI-B survey?

In the analysis, personal science teaching efficacy was coded as PSTE, and the value of the 13 items in the PSTE factor on the survey instrument (2, 3, 5, 6, 8, 12, 17, 18, 19, 20, 21, 22, 23) were added to produce an overall PSTE score for each individual. Possible PSTE scores ranged from 13 to 65. Science teaching outcome efficacy was coded as STOE, and the value of the 10 items in the STOE factor on the survey instrument (1, 4, 7, 9, 10, 11, 13, 14, 15, 16) were computed to produce an overall STOE for each participant. Possible STOE scores ranged from 10-50. These scores were computed using Microsoft excel and SPSS v.19.

A total of 110 pre-service elementary teachers participated in Phase I of the study but only 108 participants provided sufficiently complete survey data to be included in the data analysis. Of these, 100 (92.6%) were females and 8 (7.4%) were males. Two factors, participants' personal science teaching efficacy beliefs (PSTE) and science teaching outcome efficacy (STOE), were measured using the two subscales of the STEBI-B (Enoch & Riggs, 1990). The results of the analysis are shown in Table 6. The personal science teaching efficacy factor showed a mean score of 52.49 with a standard

deviation of 4.91. The science teaching outcome efficacy factor showed a mean score of

39.05 and a standard deviation of 3.36. The distribution of scores for the two subscales

are displayed in Figures 2 and 3.

Table 6

Descriptive Statistics for STEBI-B Components (N = 108)

Components	N	Minimum	Maximum	Mean	Standard Deviation
PSTE	108	39.00	65.00	52.4907	4.90945
STOE	108	28.00	47.00	39.0556	3.36233

Note. PSTE = personal science teaching efficacy; STOE = science teaching outcome efficacy.
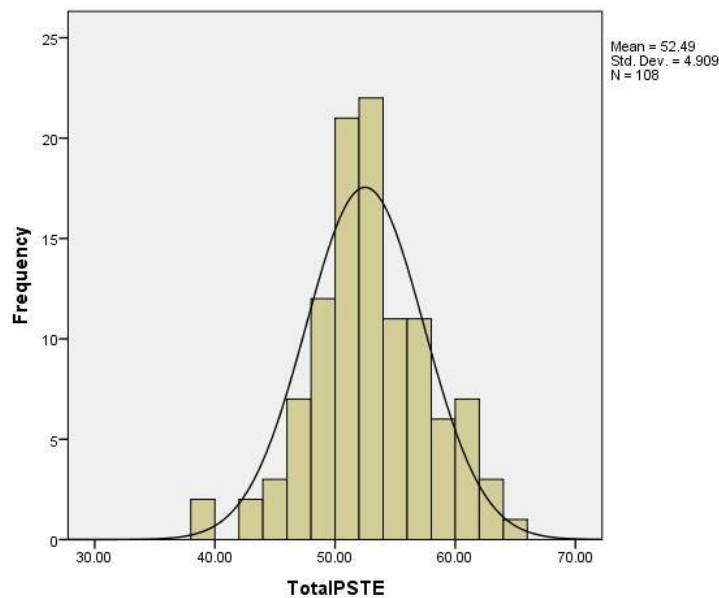
Figure 2. Distribution of Scores for Personal Science Teaching Efficacy.
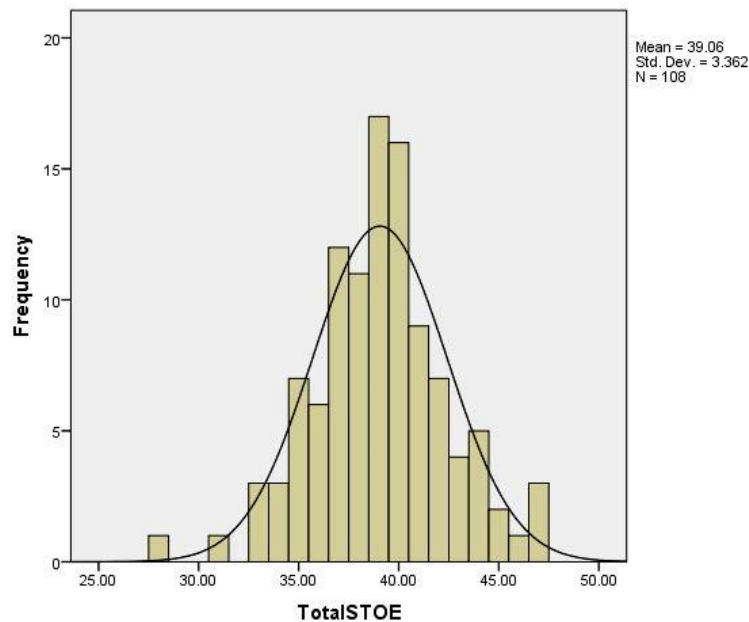
Figure 3. Distribution of Scores: Science Teaching Outcome Efficacy.

The assumptions of normality were also analyzed. Tests for normality were performed using SPSSv19. The Shapiro-Wilk test is generally considered appropriate for sample sizes smaller than 2,000. The results of the analysis are displayed in Table 7. For the personal science teaching efficacy beliefs (PSTE), *p* =.208*.* For the science teaching outcome efficacy beliefs (STOE), *p* =.132. Because the p-values exceeded the alpha value of .05, it was assumed that the total PSTE and STOE scores were normally distributed. The results of the analysis are displayed in Table 7.

Table 7

Tests of Normality for Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Efficacy (STOE)

Component	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
PSTE	.098	108	.013	.985	108	.278
STOE	.102	108	.007	.981	108	.132

[a]Lilliefors Significance Correction.
Note. PSTE = personal science teaching efficacy; STOE = science teaching outcome efficacy.

A total of 12 pre-service elementary teachers were selected for further participation in Phase II of the research which was qualitative and was conducted using case study methods. The six highest positive scores and six lowest negative scores of females on the STEBI-B were identified; and the highest positive and lowest negative male scores were also identified. Of the 12 undergraduate students selected for interview, 10 (83.3%) were females and two (16.7%) were males. The STEBI-B component and total scores, gender, and assigned identifiers for the students selected for interview are displayed in Table 8. Total scores for the highest scoring participants ranged between 103 and 110. Total scores for the lowest scoring participants ranged between 73 and 80.

Table 8

Participants by Gender and STEBI-B Scores

Student Identifier	Gender	PSTE (39-65)	STOE (28-45)	Total Score (73-110)
Highest Scores				
HR	Female	65	45	110
AW	Female	63	45	108
JN	Female	60	47	107
VB	Female	59	47	106
TW	Male	57	47	104
AS	Female	60	43	103
Lowest Scores				
BA	Female	45	28	73
NV	Female	39	35	74
BR	Female	43	35	78
EG	Female	43	36	79
MK	Male	46	33	79
TB	Female	44	36	80

Note. PSTE = personal science teaching efficacy; STOE = science teaching outcome efficacy.

Demographic data were gathered about the 12 interviewees. These data are presented in Table 9. Of the 12 interviewees, 7 (58.3%) were Caucasians, 4(33.3%) were Latin American, and only one (8.3%) was African American. A total of 10 (83.3%) of the participants were in the junior year of their teacher education programs, and only two (16.7%) were senior level students. Ten (83.3%) of the participants were educated in public schools, and two (16.7%) attended private schools. Those interviewed also expressed their preferences as to grade level to teach in the future. Approximately 34% of the participants preferred to teach the upper elementary grades especially Grades 3, 4,

and 5, but 50% preferred to teach lower elementary Grades K, 1, and 2. And 16% were

open to teach any grade at the elementary level.

Table 9

Demographic Data for Interviewees

Interviewees	Cultural Identity	Present Status	Preferred Grade Level Teaching Assignment	Schools Attended	
				Public	Private
TW	Caucasian	Junior	4, 5	X	X
HR	Caucasian	Junior	3, 4, 5	X	
BR	Latin American	Junior	2	X	
EG	Caucasian	Junior/Senior	K-2	X	
NV	Latin American	Junior	No preference	X	
TA	Caucasian	Junior	1	X	
BA	Latin American	Senior	1	X	
AW	Latin American	Junior	1	X	
VB	Caucasian	Senior	2	X	
JN	Caucasian	Junior	4, 5	X	X
MK	African- American	Junior	3, 4, 5	X	
AS	Caucasian	Junior	5	X	

Data Analysis for Research Question 2

How did pre-service elementary teachers reflect on their past positive and

negative experiences as K-12 students in science, as evidenced by critical incident

responses using Flanagan's (1954) critical incident technique (CIT)?

Research Question 2 addressed the past positive and negative incidents reported

by the participants who were interviewed using the critical incident technique (Flanagan,

1954). In reflecting on their K-12 science experiences, they reported a total of 38 critical

incidents (CI). Of the 38 critical incidents, 23 (60.5%) were categorized as positive (PE) and 15 (39.5%) as negative (NE).

Positive experiences in this analysis were related to the pre-service teachers' science related experiences in K-12 years which helped them develop positive attitudes toward science and enhanced their self- efficacy towards science and science teaching. This has been supported by earlier researchers in their study (Mulholland & Wallace, 2005; Schunk,2001). Themes which emerged that supported positive science related experiences included hands-on activities performed in science classes over the past school years and having science teachers who were supportive, encouraging and who made science concepts interesting and fun to learn.

Negative experiences (NE) with science were also categorized based on the themes that emerged from the interviews. This included lack of science related activities involving inquiry in K-12 science classrooms, teacher-centered instruction in science classes, lack of teacher support on an emotional level, textbook-based learning in science, and fear of standardized tests. These data are reflected in Table 10.

Table 10

Positive and Negative Critical Incidents of Interviewees

	Incidents		
Interviewees	Positive (PI)	Negative (NI)	Total
Highest Scores			
HR	2	1	3
AW	1	0	1
JN	3	0	3
VB	0	4	4
TW	3	1	4
AS	3	0	3
Lowest Scores			
MK	3	0	2
EG	2	2	5
BA	2	1	3
NV	1	3	4
BR	2	2	4
TB	1	1	2
Total	23 (60.5%)	15 (39.5%)	38 (100%)

Identified critical incidents were further categorized based on the school level at which they occurred: elementary, middle, or high school. Table 11 displays positive and negative experiences for the 12 participants by school level. Of the 38 experiences, the highest number (16, 42.1%) occurred at the high school level; 12 (31.6%) occurred at the middle school level and 10 (26.3%) occurred at the elementary school level. All of the interviewees reported having had their best experiences with science in the elementary years where they described indoor and outdoor activities related to science such as planting a seed. None of the interviewees was able to recall any negative experiences with science in their early years.

Although all of the incidents reported at the elementary level were positive, only half of the reported incidents at the middle school level were positive. At the middle school level, a total of four positive and eight negative incidents with science were reported. Among the reported incidents, the least number of positive incidents and the highest number of negative incidents were also recalled by interviewees in the middle school years.

Positive and negative incidents during the high school years were almost equal in number. At the high school level a total of nine positive incidents and seven negative incidents were reported.

Table 11

Positive and Negative Critical Incidents by School Level

| | School Level | | | | | |
| | Elementary | | Middle | | High | |
Participants	Positive	Negative	Positive	Negative	Positive	Negative
Highest Scores						
HR	1			1	1	
AW	1					
JN	1		1		1	
VB				2		2
TW	1			1	2	
AS	2				1	
Lowest Scores						
MK					2	
EG	1		2	1		1
BA	1				1	1
NV			1	2		1
BR	1			1	1	1
TB	1					1
Total	10	0	4	8	9	7
Percentage	26.3%	0	10.5%	21.1%	23.7%	18.4%

Emergent Themes for Research Question 2

Hands-on Learning Experiences

Assertion 1: The important role that hands-on learning experiences played in influencing students' perceptions of science teaching and learning were evident in the mostly positive comments students had about their hands-on learning activities

Hands on activities related to science activities where students were "doing" science. Doing science refers to experiencing science through activities. In the analysis of the positive and negative experiences with science, it was found that most of the participants who were exposed to hands-on science learning were positive in their beliefs about science, and they found science to be interesting and fun. In discussing their positive experience with science activities in K-12 classrooms, most of the participants cited hands-on activities as the most interesting part of science learning. Another interesting observation was that most of the hands-on activities occurred at the elementary level. Many of the interviewees had better experiences with science in the elementary years. They described indoor and outdoor activities related to science such as planting a seed, dissecting eyeballs, and recording weather. None of the interviewees was able to recall any negative experiences with science in their early years. The transcribed coded interviews revealed that 83% of positive incidents were reported in the elementary years of school from Kindergarten to Grade 5. Some examples of interviewees' reflections follow:

AW was excited to describe her fourth grade activities with science. She reflected:

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I think fourth grade sticks out to me the most, because we did a lot of hands on activities in that grade. I don't remember. I think it was a lot of science things. We would go outside. We would plant seeds and watch them grow. We made like a solar oven, and like, I never hear about people doing that anymore but that was really hands on, and those are the things I really remember is all the hands on activities.

Similarly, JN had positive experiences with her high school anatomy and physiology class. She expressed her interest with that class: "And high school my most favorite anatomy and physiology and that was cool. She was really hands-on, like with dissections, and that's when I really got to, of course, do the hands on, which sparked my interest in science".

[BA] reflected on her positive experiences with science by describing her fourth grade and seventh grade teachers. As she recalled, her fourth grade class was fun filled: "I can say definitely fourth grade stands out the most because we planted different, like, flowers, and we were monitoring them for different parts of our plant cycle unit and that stood out for me."

Based on the findings for this research question, it was inferred that hands-on activities in science classes were an essential element of the most positive science experiences interviewees recalled as occurring in their K-12 years. These experiences contributed to positive beliefs and high self-efficacy of the interviewees.

<u>Teacher-centered Education</u>

Assertion 2: Lack of science related activities and traditional methods of learning in their school years may have lowered participants' confidence about science learning.

Negative experiences were related to a lack of science related activities in classrooms, making science a boring subject to learn. Participants who expressed their negative beliefs towards science were exposed to teacher-centered learning, textbook based learning of science in their school years where they were passive learners. Participants expressed their negative beliefs towards science in their responses.

TW said, "Unfortunately most were direct teachers, and not really too many activities." BR had similar views: "Read the text, take the test, a boring way of doing science." VB, who had the highest number of negative experiences in her school years, remembered her biology class:

> I went into high school, and I had this biology teacher who was a football coach, and he was just into sports. He didn't want to teach his class. He gave us worksheets and made us watch Nemo for a class assignment, and I didn't learn anything.

The findings revealed that teacher-centered learning does not improve student interest in science where teachers teach and students are passive learners. In traditional teaching, the teacher conducts most of the activities, and students are not motivated in the learning process.

<u>Teacher-student Interaction</u>

Assertion 3: Interactive learning in science classrooms between the teacher and student enhanced better learning and positive beliefs about science.

Teacher-student interaction is important (Darling-Hammond, 2000). Teachers who are better communicators show interest in their students, behave in a friendly manner, and foster confidence in their students. Such teachers will be good listeners, show confidence and enthusiasm for teaching, and be very supportive. Participants in this study recalled positive interactions with their teachers. Examples of their comments follow:

HR recalled her experience with her second grade teacher, "I know my second grade teacher was really great, she taught all the subject,um, I think it was her enthusiasm of her teaching. She loved her students and she loved her job."

BA recalled a seventh grade positive experience with the teacher whom she described as caring and motivating: "I was a shy student, and she knew I needed to be pushed, so she pushed me to present in front of the class, and stuff like that, and you can tell that she cared."

AS recalled her fifth-grade teacher as inspirational.

I had some really great teachers that inspired me to be a teacher, um like I go to help out in the classroom of my fifth-grade teacher who is still teaching, and she is one of the main people that really inspired me to be a teacher and love school.

In their interviews, pre-service elementary teachers recalled that teachers who communicated well with them in their science classes and who cared and supported them academically and emotionally made a considerable impact on their positive beliefs' towards science and science teaching.

Pedagogy and Content

Assertion 4: The traditional method of science instruction where teachers deliver information to students through textbooks and lectures did not promote positive self-efficacy about science for these teachers.

In teacher-centered education, inquiry skills required to do science are delivered directly to students by teachers. This often ensures that students do not get personally involved in the doing of science, and this lowers their self-confidence in their science abilities.

Several participants indicated they did not gain knowledge in science with traditional methods of learning and that led them to dislike science. Two participants, BA, and TB, spoke of their negative experiences with a chemistry class in high school. BA had difficulties understanding the chemistry teacher. Reflecting back on her negative experience with science she expressed, "No one made me think it was fun and amazing."

TB was also uncomfortable with her chemistry class in high school. She remarked, "The teacher told us he was a chemist like 45 million times, but I think it was hard for him to teach; he just like skipped so many steps, he couldn't teach it to us."

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Negative beliefs towards science were also attributed to teacher-centered learning. Participants reported incidents where science teaching was textbook-based, teachers would lecture, and student would be passive listeners. This method of learning science did not allow students to interact with teachers in their learning process and thereby affected their communication skills. This method of instruction gave them limited opportunities to express themselves by asking questions and directing their learning in science. These unexciting experiences with science in the K-12 years led to the negative attitudes toward science of some of the interviewees. In summary, after analysis of participants' negative experiences, it was revealed that traditional teaching methods, i.e., pedagogy, in science classes and lack of teacher -student interaction in their K-12 years did not facilitate positive beliefs towards science and science teaching.

Teacher Knowledge and Qualifications

Assertion 5: Science teachers who are qualified to teach and who also possess the science content knowledge may make better science teachers who may contribute to building students' confidence about science.

Researchers such as Darling-Hammond (2000) have reported that teachers' academic qualifications significantly impact student performance. The 1999 NSTA position statement on teacher professionalism emphasized quality science instruction and called for all teachers to be responsible and provide students with the high quality science education they deserve. The NSTA also stressed the importance of recognizing the needs of students to make learning more productive. In this study, half (9, 50%) of the

participants disliked science at some point in their K-12 years because of their science

teachers and methods of instruction. The common repetitive words used by the

participants for their negative high school chemistry experience were "hard" or "awful"

or "crazy."

Participants' reports of past incidents with science included negative incidents in

their high school science classes where teachers were not particularly attentive to the

needs of the students. Two incidents in chemistry classes, one incident in a biology class,

and one in a veterinary class were reported. These incidents lowered students'

confidence in their science abilities and led them to dislike science. In discussing her

chemistry teacher, one participant expressed her lack of understanding of what her

chemistry teacher taught who simply did not care about her students. The other

participant was uncomfortable with chemistry class because her chemistry teacher, who

was a professional chemist, had the content knowledge but was unable to engage students

in pedagogy. Negative experiences related to a high school veterinary class were also

reported by a participant. VB lamented,

> We didn't do anything. There were no animals, no hands on. It was just lecture
>
> and textbook, and that was it. Like, we made cookies one time for a class activity,
>
> and I was like, what does cookies have to do with anything science related?
>
> Nothing ? Okay, I learned how to bake in my science class.

VB was also disappointed with her high school biology teacher who was the

school's football coach. She reported that this teacher had students watching videos like

"Nemo" for class assignments and was not interested in teaching biology. For VB, the

lack of proper guidance and instruction in science in her high school years led to failure in understanding basic science concepts and resulted in a dislike of science. She believed that her K-12 experiences with science were so poor that she literally disliked science and thought it was a very difficult subject.

Some interviewees described their past experiences with science teachers as very rewarding. HR remembered her seventh-grade biology teacher who she felt did well in teaching biology. She liked the dissections and remembered that she earned good grades in this class. MK recalled his positive experience with a seventh-grade science teacher and the activities in that class that challenged him. MK had high regard for his senior year anatomy and physiology teacher whom he admired for explaining science in an understandable manner.

Hands-on activities in science classes were an essential element of the positive science experiences most of the interviewees recalled as the best that happened in their K-12 years. Lack of proper guidance and support from teachers were the main reasons for negative experience with science teachers in their K-12 years, especially in high school where teachers could have made science more interesting for students. The critical incidents recalled by participants were largely related to the characteristics of the teachers who taught them science and the activities involved in the science instruction.

Findings about the beliefs of pre-service elementary teachers about science based on their past experiences revealed several emergent themes which included: (a) hands-on activities, (b) teacher-centered education, (c) teacher-student interaction, (d) pedagogy

and content, and (e) teacher knowledge and qualifications. These themes, set in a context of need-based instruction, which focused on the needs of all students, were all important contributors in the development of positive and negative beliefs and attitudes about science.

Data Analysis for Research Question 3

What sources of self-efficacy were reflected in pre-service elementary teachers' positive and negative experiences in science as K-12 students?

The third research question addressed the sources of self-efficacy that were prominent in interviewees' past experiences with science in the K-12 years. The conceptual framework for this question was based on Bandura's (1977) self-efficacy theory. He identified four sources of self-efficacy. Mastery experience is the most influential source of self-efficacy where success in an activity raises self-efficacy and failure lowers it. Vicarious experience is seeing others perform a task successfully and involves social comparison made with teachers, peers, or even family members. Social persuasion also influences self-efficacy in that positive words can help in encouraging one's self confidence while negative persuasion can weaken an individual's confidence and self-esteem. In emotional/physiological experiences, encouragement raises self-efficacy, and anxiety and stress lowers it. The four sources of self-efficacy were used to analyze the data elicited from interviewees in their recollection of past positive and negative critical incidents in their K-12 experiences with science.

A total of 38 critical incidents were reported by the interviewees. Table 12 contains the specific sources associated with each of the identified incidents. Over half of the incidents (22, 57.9%) were categorized as mastery experiences, and they were almost equally divided between positive (12, 31.6%) and negative (10, 26.3%) experiences. Social experiences accounted for eight (21.1%) of all incidents. Fewer incidents were associated with vicarious (5, 13.2%) and emotional/physiological (3, 7.9%) experiences. The detailed results, including examples of interviewees' comments supporting this categorization of incidents by the four sources, are presented in the following sections.

Table 12

Sources of Self-efficacy: Positive (PE) and Negative (NE) Experiences

		Sources of Self-Efficacy							
		Mastery		Vicarious		Social		Emotional/ Physiological	
Interviewees	Incidents	PE	NE	PE	NE	PE	NE	PE	NE
Highest Scores									
HR	3	1		1					1
AW	1	1							
JN	3	1		1		1			
VB	4		3				1		
TW	4	1	1	1		1			
AS	3	2		1					
Lowest Scores									
MK	3	1		1		1			
EG	4	1	1			1	1		
BA	3	1	1			1			
NV	4	1	2						1
BR	4	2	1						1
TB	2		1			1			
Total	38	12	10	5	0	6	2	0	3
Percentage	100%	31.6%	26.3%	13.2%	0	15.8%	5.3%	0	7.9%

Mastery Experience

Assertion 6: Mastery experiences of pre-service teachers largely depended on students' pre-existing knowledge in science, the various tasks accomplished in their science classes, and the degree of past support they have received as students of science from their own teachers, family, and peers.

According to Bandura (1977), the success level of mastery experiences defines positive self-efficacy. Failures in mastery experiences lower self-efficacy. For some participants, their past accomplishments as students in science classes and the positive care and support they received increased their self-efficacy beliefs about science. Self-efficacy was increased by science related indoor and outdoor activities ranging from dissections in biology class to recording weekly weather, understanding the phases of moon, and enjoying and appreciating the knowledge gained about science. Past negative experiences in science classrooms that included a lack of science related activities, failing to understand the concepts in chemistry class, failure in tests were all the negative mastery experience recalled by the interviewees. These experiences lowered interviewees' self- efficacy beliefs toward science and contributed to discomfort with and dislike of science. VB's lack of mastery experience with science lowered her self-efficacy because of the lack of activities in science class, exposure to teacher centered and textbook based learning where concepts of science were unclear, and failure in tests. She (VB) recalled, "You can ask me what an atom is. . . . I don't know, because back in middle school and high school I was getting taught Nemo, so I didn't have that prior knowledge to be able to learn."

Lack of science related activities lowered VB's confidence in her science abilities. She talked about the activities in the veterinary class which was teacher-centered and textbook based and reported that she learned to bake cookies in this class. She described it as an "awful experience."

BR and TB, who were low scorers, had a negative mastery experience in their chemistry class during their high school years. The chemistry class was described as hard and boring because students did not understand the concepts, and it was textbook based learning. Negative beliefs were reinforced which in turn lowered self-efficacy. BR stated the following: "I mean, chemistry in high school was crazy, was really difficult. I didn't understand half of the stuff that was going on, so that probably made it worse." Reiterating a similar problem, TB recalled,

> Chemistry was very hard for me. He was a real chemist I think it was hard for
> him to teach us, he just, like, skipped so many steps, so he couldn't really explain
> the steps, so he would just be writing on the board.

Two interviewees, HR and TW, had a natural desire to learn science. Thus, they motivated themselves to engage in science related activities independently. Their fascination with astronomy, marine biology, and geology was evident in their interviews; and their past experiences with science were mostly positive. The STEBI-B scores of both of these participants were high, and both had high self-efficacy with regard to science and science teaching.

Vicarious Experience

Assertion 7: Having role models as science teachers may be influential in developing self-efficacy about science among prospective teachers.

If the prospective teachers' past experiences with their science teachers were inspiring, their beliefs in their own efficacy were likely to have increased. In contrast, past experiences that did not inspire had the potential to lower their beliefs in their own efficacy (Bandura, 1997).

The past positive experiences with science in K-12 years reported by the interviewees reflected back on the teachers who inspired them to enter the teaching profession, encouraged them to understand science through inquiry, and encouraged them to be better citizens. One of the participants (TW) shared his high regard for his favorite science teacher in his middle school as follows:

> He did a lot of experiments and stuff that was hands on. I had a lot of respect for him. He just wasn't my teacher, but he was a great teacher. He actually reminds me a lot of Dr. X [college professor].

In his discussion, MK referred to inspiration provided by one of his present science instructors.

> Uh, I really like my science class now. I'm in the Teaching Elementary Students Science course with Dr. X [college professor]. He would demonstrate and then have us do the same thing while he demonstrated, and that's important for education because it's not just about the teacher teaching, but how you get the students to respond in the classroom, and apply those science skills.

Two participants recalled their junior year teachers who inspired them to pursue teaching. TW remembered a science teacher during his junior year for whom she had great respect and admired the way he taught inquiry based science. JN proudly remembered her teacher and described the inspiration she provided:

Ms. Marteer in high school, because she was the one, she was the one who made me want to be a teacher. She was the one who inspired me to really want to teach because she was really hands-on, like with the dissections, which sparked my interest to be like her.

AS, one of the highest scoring interviewees on the survey, expressed a great regard for her fifth-grade teacher:

I had some really great teachers that inspired me to be a teacher, um like I go to help out in the classroom of my fifth-grade teacher who is still teaching, and she is one of the main people that really inspired me to be a teacher and love school.

Few participants in this study had role models who inspired them to science and science teaching. Four participants indicated they believed they had the confidence to do better as future teachers of science .

Social Persuasion

Assertion 8: Teachers' and other adults' words of encouragement may positively affect students' self-efficacy, and a discouraging comment may lower self-efficacy.

According to Bandura (1977), positive words can build one's self-confidence and enhance one's self efficacy. The participants who recalled positive experiences in their

K-12 years revealed that teachers and other adults who were caring and supportive and who encouraged them to do better contributed immensely to their high level of self-efficacy.

TW shared an example of an inspirational teacher:

But, um, the most inspiring teacher I ever had was my senior year of high school in my honors English class, you know, she would encourage me to do that, and maybe give me a little more time to finish the projects, and she was really individualized with all her students. She took time with all her students.

BA reflected on the positive influence of one of her seventh-grade teachers:

The teachers who helped me the most, like seventh grade I had a science teacher, and I don't remember the content, but I remember her. She knew I was a shy student, and she knew I needed to be pushed, so she pushed me to present in front of the class, and stuff like that, and you can tell that she cared. She cared if you learned the material. She cared if you were having a bad day.

MK remembered his father as a great source of encouragement for him. He stated, "My dad was helpful too, because he didn't want me to be lazy. He would always give me the extra encouragement and the drive to do well, stay focused."

Bandura (1977) also alluded to the power of negative comments in lowering confidence and self-esteem. The participants in this study recalled negative experiences with their teachers who discouraged them with negative words such as "You can never" that lowered their self-efficacy beliefs.

EG recalled her negative experiences with her third grade teacher: "My third grade teacher who told me that the thought that I would ever graduate from high school would be beyond him and that he didn't even think that would be possible."

VB commented negatively on her veterinary class teacher:

That was my vet class. She was a female teacher, but like I said, she was one of our. . . she was so focused on trying to get that class out and trying to get kids to take it that she didn't focus on teaching.

Physiological/Emotional Experience

Assertion 9: Emotional/physiological experience, in the form of support from family and teachers on an academic and personal level, raises one's self-efficacy; but unpleasant events, e.g., failure in performing a task or on a test and socio-economic factors, may lower one's self-efficacy.

Bandura (1977) expressed the belief that a fear of failure during tests or an activity related to science could raise anxiety levels which indirectly lowers self-efficacy. An increased level of anxiousness can have a detrimental effect on the pre-service elementary teachers' self-efficacy to teach science. Learning does not happen under stressful conditions. In this study, the participants reported that failure on tests, lack of support, socio-economic conditions contributed to lower self-efficacy. In contrast, support and encouragement from family and teachers on an emotional level enhanced levels of self-efficacy. The participants who moved from school to school in their early years as students reflected on their negative experience on an emotional level.

Experiences with urban schools, bullying, disintegrated family, low economic status at home were vital in contributing to their low self- efficacy.

HR remembered her middle school and its negative influence on her academically. She stated,

We were in a lower income neighborhood and the school was really going through some troubles, I think ,with just the behaviors and the students and the whole morale of the school, and I moved there, and I got made fun of, and no one really seemed interested in learning, and it was just the whole classroom was brought down with behavioral problems and classroom management issues, and it was a big issue, and it was difficult for me to keep learning, so I started getting into trouble and, you know, not hanging out with the best people, and from there on throughout out high school my grades suffered, and before that I was a straight A student.

Emotional support from family members for some participants in the form of encouragement and support raised their self-efficacy. These participants had positive beliefs about science and teaching. TB described her fifth-grade teacher as one who influenced her to improve her self-efficacy:

Fifth grade--I feel like the teacher made it, like she took an effort to know you. She was very personal and I thought that was very important. Yeah, and I ended up loving her. She was nice, and um. . .

BA, a Latin American student, believed that ESOL students should get extra support from their teachers to keep up with their fellow students. She shared the following emotional experiences during her K-12 years that affected her self-efficacy beliefs:

> Others would just leave me in a corner, and I would do my work. I am able to work alone, I don't have to work in groups to understand it, so since I wasn't one of the rowdy students I would be left alone to do what I needed to do, and that isn't always the best way to go about it, so yeah. And then I had my dad. My dad is proficient in English, but my mom isn't and since he was out in the military I didn't have support at home, and teachers didn't really look into that or realize it. That caused issues.

In summarizing the results of the analysis for Research Question 3, it can be reported that mastery experience (12) contributed to the pre-service teachers' levels of self-efficacy in science. The past experiences of the pre-service elementary teachers also revealed that social persuasion (6) and vicarious experiences (5) enhanced their self-efficacy with regard to science rather than lowering it and inspired a number of the interviewees to teach in schools. Emotional/physiological experiences lowered the self-efficacy beliefs of some interviewees (3) and raised the self-efficacy beliefs of others.

Data Analysis for Research Question 4

To what extent did participants believe that positive and negative incidents in K-12 science would affect them as science teachers?

To answer Research Question 4, participants' responses to two interview questions were analyzed. Interviewees were asked (a) Looking back at your past positive and negative incidents with science, how does it affect you today? and (b) How do you think your past experiences with science in your K-12 years affect you as a future teacher of science? The 12 participants who were interviewed responded to both of these questions with confidence. Table 13 contains a summary of the ways in which interviewees responded to the two questions. The table contains a synthesis of data by the researcher obtained from the statements of the interviewees and the results of their STEBI-B survey responses. These data were used in reaching a determination as to the present and future impact of past experiences on the self-efficacy of the pre-service elementary teachers who were interviewed.

Table 13

Summary: Interviewees' Present Level of Self-efficacy and Future Expectations

Interviewees	Present Self-efficacy	Expectations as a Future Teacher
TW	High self-efficacy; natural liking towards science; fascinated to astronomy and marine biology; past experiences made him independent and confident;	Caring and compassionate; hands on activities in science making it fun and interesting.
HR	High self-efficacy; loves science and passionate about it; hobbies were reading non-fiction books related to science; highly confident to teach.	Make science teaching interesting using hands on activities.
BR	Moderate self-efficacy; past negative experience with FCAT lowers her self-efficacy to teach 4th & 5th grades; past positive experiences makes her confident to teach the little ones(kg-2nd grade).	Compassionate to students, go an extra mile to make science fun and interesting with hands on activities.
EG	Low self-efficacy; prior negative experiences lowered her self-efficacy; fear to teach 3rd, 4th & 5th graders; present course sce3310 has improved her self-efficacy.	Wanted to incorporate all she learned in SCE3310 course into future science classrooms.
NV	High self-efficacy; love for school and teachers; like to interact with students one on one in the learning science; confidence to teach.	Hands on activities in science classrooms; caring and supportive to students in future classrooms.
TB	High self-efficacy; past positive experiences in science enhanced her self-efficacy; believes in group study and applying teaching methods based on the topic.	Carry forward her positive experience with science to future classrooms; make science fun and interesting using hands on activities, group activities; caring and supportive.

Interviewees	Present Self-efficacy	Expectations as a Future Teacher
BA	Moderate self-efficacy; gained confidence over the years; ants to change her personal negative experiences with k-12 into a positive one.	Science fun and interesting; hands on activities, compassionate and supportive to students who donor receive support from home academically.
AW	High self-efficacy; positive self-efficacy; sociable nature, loves to teach children, believes in learning by doing science; confident to teach little children.	Science fun and interesting by using hands on activities and incorporating media and technology.
VB	Low self-efficacy; present science course sce3310 has enhanced her self- efficacy; building on her confidence to teach.	Excited to teach science; wanted to make science fun and interesting with hands on activities and flexible to the needs of the students.
JN	High self-efficacy; incorporate all she learned into future classrooms; highly confident to teach.	Science instruction fun and interesting; hands on activity.
MK	High self-efficacy; past positive experiences enhanced self-efficacy; developed self-discipline.	Incorporate all the science skills (experiments, concept formation, research) in science classrooms.
AS	High self-efficacy; more knowledgeable in science, be proficient teacher; past positive experiences with science has made her confident.	Science fun filled activity; more indoor and outdoor activities related to science.

Impact of Past Incidents on Present Beliefs in Science

Past experiences with science during their K-12 years had a significant impact on 10 of the 12 interviewees' present self-efficacy beliefs. Nine of the 12 participants reported that their past experiences with science, especially mastery experiences, had contributed mainly to their high self-efficacy beliefs toward science and science teaching.

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They indicated that their past positive experiences with science had made them more resourceful and compassionate towards teaching and students.

Participants shared various reasons why they saw their K-12 science experiences as positive and negative. The participants who scored high on the STEBI-B survey were exposed to positive science related experiences and hence shared more positive perceptions towards their confidence to teach science in elementary classrooms in the future. Their self-efficacy levels were relatively high. On the other hand, students with low scores on the STEBI-B survey had more negative experience in their K-12 years and reportedly were less confident. VB had no positive experience with science in her K-12 years, and this fed her dislike of science and lowered her self-efficacy towards teaching science in future classrooms.

It was also revealed that, for this group of pre-service elementary teachers, all of the negative critical incidents had occurred during their middle and high school years. In interviews, participants attributed this to a lack of understanding of the science concepts and lack of attention from the teachers in their science classrooms. Various other reasons that may have impacted teachers' beliefs about science included: limited science in elementary school and teacher-centered and textbook-based learning. As students, these pre-service teachers began to view science as uninteresting. They learned science through memorization of facts only to get through their examinations.

Half (9, 50%) of the participants disliked science at some point in their K-12 years because of their science teachers and methods of instruction. The common repetitive words used by the participants for their negative high school chemistry

experience were "hard" or "awful" or "crazy." One of the participants (BA) was unable to comprehend what the teacher taught, and two others (BR and TB) could not connect to Chemistry and the Chemistry teacher at all.

Impact of Past Incidents on Future Science Teaching

The pre-service teachers' past mastery experience with science enhanced their self-efficacy beliefs to the extent that they wanted to be better science teachers, incorporating all the science related skills necessary in science classrooms. In discussing the impact of past incidents on their future science teaching, all of the 12 interviewed participants wanted to make science interesting and fun and wanted to incorporate hands on activities into future science teaching. Participants were also keen on incorporating media and technology in the learning of science. Most of the interviewees expressed a desire to be compassionate and caring toward students in their future classrooms, especially students who were in need, and those who did not receive academic support at home. Almost all the interviewees believed that being compassionate, caring, and motivational were primary roles of a teacher, especially in elementary schools where the sensitive nature of little children needed to be considered.

Two of the participants expressed their discomfort with FCAT and wished to make it less stressful for future students they intended to teach. Three of the 12 participants were low in self-efficacy because of their past negative experiences with science. However, all the participants reported that they were eager to teach.

The participants with low scores on the STEBI-B survey were uncomfortable, anxious, and lacked confidence with teaching science in the future. These participants were apprehensive because of their negative experiences with science in their K-12 years, often as a result of experiencing traditional text-book based science instruction and lack of hands-on science related activities during their schooling. The participants with low self-efficacy beliefs in science also reported that the present course (SCE3310) in which they were enrolled was useful in gaining the science knowledge that they lacked in order to apply it in future classrooms as teachers of science.

<div align="center">Summary</div>

This chapter has provided an analysis of the data for the four research questions which guided the study. The results of the quantitative analysis, in which 12 case study participants were identified, was presented and explained. The data obtained from 12 face-to-face interviews was presented. This included the identification of 38 critical incidents, five themes which emerged during the identification process, and linkage of positive and negative experiences with four sources of self-efficacy. Chapter 5 includes a summary and discussion of the findings. Also presented are the limitations related to the study, implications for practice, and recommendations for future research.

CHAPTER 5
SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Introduction

The purpose of this case study research using quantitative and qualitative methods was to determine pre-service elementary teachers' self-efficacy and beliefs toward teaching science based on their past K-12 experiences. Also explored was the extent to which pre-service teachers believed that positive and negative K-12 science incidents (a) have contributed to their level of self-efficacy, (b) will affect them as elementary teachers, in future classrooms. The conceptual framework for this study coalesced around two key attributes--teachers' beliefs and science self-efficacy to investigate how teachers' past science experiences may have affected their current beliefs and science self-efficacy.

In the conceptual framework, teachers' self-efficacy and beliefs were elucidated using the Science Teaching Efficacy Belief Instrument (STEBI-B) and Flanagan's (1954) critical incident technique to provide insights on how teachers' past experiences may have affected their beliefs and science teaching self-efficacy which may impact their future science teaching. The past two decades has seen a significant contribution of research on teacher beliefs and their impact on student learning. Earlier studies on pre-service elementary teachers self- efficacy beliefs towards science teaching has largely been quantitative in nature (Bleicher, 2004; Bursal, 2012; Enoch & Riggs, 1990). Furthermore, the few qualitative studies conducted on pre-service elementary teachers beliefs collected data on common variables such as inquiry based learning in classrooms

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(Brown & Melear, 2006) and computer attitudes (Teo et al., 2008). This study sought to understand pre-service elementary teachers' beliefs and influence of various sources of self-efficacy towards science using four research questions.

Research Questions

1. What were pre-service elementary teachers' initial personal science teaching efficacy (PSTE) and science teaching outcome efficacy (STOE) as measured in the STEBI-B survey?

2. How did pre-service elementary teachers reflect on their past positive and negative experiences as K-12 students in science, as evidenced by critical incident responses using Flanagan's (1954) critical incident technique (CIT)?

3. What sources of self-efficacy were reflected in pre-service elementary teachers' positive and negative experiences in science as K-12 students?

4. To what extent did participants believe that positive and negative incidents in K-12 science would affect them as future science teachers?

Summary and Discussion of Findings

To answer Research Question 1, as to pre-service elementary teachers' initial personal science teaching efficacy (PSTE) and science teaching outcome efficacy (STOE), 108 pre-service elementary teachers completed the STEBI-B survey. Student scores obtained during Phase I of this research were used primarily to identify high- and

low-scoring pre-service elementary teachers on the STEBI-B who were then invited to participate in Phase II of the research, a qualitative case study involving 12 subjects. High PSTE and STOE survey scores indicated high personal science teaching efficacy and high science teaching outcome efficacy. Students who scored high on the survey largely agreed with statements such as "I will continually find better ways to do science" and "I know the steps necessary to teach science concepts." The high scores in their personal science teaching efficacy beliefs were due to positive science experiences in their school years and they were confident to teach science in future classrooms.

Findings suggest that a majority (66, 61.5%) of the 108 participants had higher PSTE scores ranging from 52 to 65. This indicated that their personal confidence in teaching science at the elementary level was high. No evidence was gathered on all participants, but from past research and given students' levels of confidence, one could assume that their positive outcomes were connected to positive past science experiences. Responses to questions related to teaching science concepts, "I know the steps necessary to teach science concepts," monitoring science experiments in science classrooms and answering science related questions, "When teaching science I will welcome student questions," were strongly agreed upon by majority of the participants. These statements revealed their strong and positive personal science teaching self-efficacy beliefs.

Similarly, a majority (69, 64%) of teachers had STOE scores ranging from 39 to 47. This range of scores indicated that participants were positive about the outcome of effective science teaching. This outcome was reflected in their positive responses to the STOE items related to teacher effectiveness. Answers to STOE items related to teaching

outcomes such as, "A child showing more interest in science is probably due to performance of the child's teacher," "Extra attention from teachers increasing student performances in science, and "When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher," were strongly agreed upon responses, indicating that a majority of these pre-service elementary teachers were positive about the outcome of effective science teaching in future classrooms.

In contrast, participants with low scores on the survey were either uncertain or they disagreed with the above mentioned survey items. Students who scored low on the surveys revealed that their personal science teaching efficacy and their science teaching outcome efficacy were on an average level. In responding to items about teaching science concepts, being able to answer science questions, and welcoming science questions from students, low scoring participants indicated they were unable or uncertain about their capabilities to teach science well. Their past experiences with science were not very impressive, being largely textbook-based with limited science related activities. Most of the participants' low scores indicated that they were less confident about science teaching. Earlier researchers have shown that students with high STEBI-B scores were more inclined to be positive towards their teaching abilities in science as compared to students with low scores on their STEBI-B survey (Yilmaz et al., 2007).

Research Question 2 called for 12 pre-service elementary teachers to reflect on their past positive and negative experiences as K-12 students in science in individual interviews conducted by the researcher using Flanagan's (1954) critical incident technique (CIT). In reflecting on their past positive and negative experiences with

science in their K-12 years, the interviewed participants reported a total of 38 critical incidents, 23 (60.5%) of which were categorized as positive (PE) and 15 (39.5%) as negative (NE). Five themes emerged from the interviews regarding past experiences: (a) hands-on activities, (b) teacher-centered education, (c) teacher-student interaction, (d) pedagogy and content, and (e) teacher knowledge and qualifications. These themes led to the following five assertions:

Assertion 1: The important role that hands-on learning experiences played in influencing students' perceptions of science teacher and learning were evident in the mostly positive comments about their hands-on learning activities.

Assertion 2: Lack of science related activities and traditional methods of learning in their school years may have lowered participants' confidence about science learning.

Assertion 3: Interactive learning in science classrooms between the teacher and student enhanced better learning and positive beliefs about science.

Assertion 4: The traditional method of science instruction where teachers deliver information to the students through textbooks and lectures did not promote positive student self-efficacy about science.

Assertion 5: Science teachers who are qualified to teach and who also possess science content knowledge may make better science teachers who may contribute to building students' confidence in science.

With regard to positive and negative experiences, fairly equal numbers of positive experiences occurred during the elementary and high school years, with middle school experiences being recalled as negative. The positive experiences with science activities

in K-12 classrooms were largely related to hands-on activities and were described as the most interesting part of science learning. On further analysis it was found that most of the hands-on activities occurred at the elementary level. As one of the participants (AW) reflected about her fourth grade classroom,

I think fourth grade sticks out to me the most, because we did a lot of hand-on activities in that grade. We would go outside. We would plant seeds and watch them grow. We made like a solar oven, and like, I never hear about people doing that anymore but that was really hands on, and those are the things I really remember is all the hands on activities.

Negative experiences were related to a lack of science related activities in classrooms, i. e., pedagogy and content, making science a boring subject to learn. These findings were supported by those of prior researchers. Bursal (2012) and Varma (2007) argued that past negative experiences as science students may have a negative effect on their beliefs towards science and science teaching. Participants who expressed their negative beliefs toward science indicated they had been passive learners who were exposed to teacher-centered and textbook-based learning of science in their school years. TW recalled that, "Unfortunately, most were direct teachers and not really too many activities." BR had similar views: "Read the text, take the test, a boring way of doing science."

The past negative incidents towards science were often related to teacher-centered learning and to a lack of teacher-student interaction. The participants in this study reported incidents where science teaching was textbook-based, and teachers would

lecture and student would be passive listeners. This method of learning science did not allow students to interact with teachers in their learning process and thereby affected their understanding of science concepts as well. This method of instruction gave them limited opportunities to express themselves by asking questions and directing their learning in science. The result of what were thought to be boring experiences with science in their K-12 years contributed to the negative attitudes toward science of some participants.

For some, the past experiences with science teachers were rewarding. HR remembered her seventh-grade biology teacher who she felt did well in teaching biology. MK recalled his positive experience with his senior year anatomy and physiology teacher whom he admired for explaining science in a clear and understandable manner. The importance of teacher knowledge and qualifications was a theme that repeated itself in the interviews. Hands-on activities in science classes was an essential element of the positive science experiences interviewees recalled as happening in their K-12 years. Lack of proper guidance and support from teachers were shared as reasons for negative experiences with science in the K12 years, especially in reference to the high school years.

Research Question 3 called for an examination of the previously identified 38 critical incidents recalled by the pre-service elementary teachers to identify the sources of self-efficacy associated with them. Bandura's (1977) four sources of self-efficacy (mastery experiences, vicarious experiences, social persuasion, emotional/physiological experiences) provided the framework for this analysis. The analysis of data related to the four sources of self-efficacy led to four additional assertions.

Assertion 6: Mastery experiences of pre-service teachers may largely depend on students' pre-existing knowledge in science, the various tasks accomplished in their science classes, and the degree of past support they have received as students of science from their own teachers, family, and peers.

Assertion 7: Having role models as science teachers may be influential in developing self-efficacy about science among prospective teachers.

Assertion 8: Teachers' and other adults' words of encouragement may positively affect students' self-efficacy, and a discouraging comment may lower self-efficacy.

Assertion 9: Emotional/physiological experience, in the form of support from family and teachers on an academic and personal level, raises one's self-efficacy; but unpleasant events, e.g., failure in performing a task or on a test and socio-economic factors, can lower one's self-efficacy.

Mastery experiences, both positive and negative, were the predominant source (22, 57.9%) of self-efficacy for those interviewed. Researchers have shown through years the importance of mastery experiences with science in the K-12 years in order to positively impact pre-service teachers' self-efficacy beliefs about science (Britner & Pajeras, 2006; Tosun, 2000). Academically for some participants the past accomplishments in science class as students and the positive feedback they received from their teachers in the form of care and support emotionally and academically raised their self- efficacy beliefs towards science. Past negative experiences in science classrooms included lack of science related activities, failing to understand the concepts

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in chemistry class, failure in tests were all associated with a lack of mastery. These were recalled by participants as having lowered their estimation of their science capabilities.

Vicarious experiences were also mentioned by participants where role models as science teachers were a powerful influence on developing high self-efficacy towards science. JN, one of the high scorers on the STEBI-B survey, proudly remembered her teacher and said,

> Ms. Marteer in high school because she was the one, she was the one who made me want to be a teacher. She was the one who inspired me to really want to teach because she was really hands on like with the dissections, which sparked my interest to be like her.

AS, another high scoring student on the survey, had a great regard for her fifth-grade teacher:

> I had some really great teachers that inspired me to be a teacher, um like I go to help out in the classroom of my fifth grade teacher who is still teaching, and she is one of the main people that really inspired me to be a teacher and love school.

Social experiences also influenced participants. Bandura(1977) stressed the importance of positive words to encourage the development of self-confidence, and noted that negative thoughts could easily discourage a learner and undermine self-esteem. Participants in this study recalled both positive and negative experiences with teachers. Some were discouraged by expressions such as "You can never. . ." or as EJ stated, "My third-grade teacher who told me that the thought that I would ever graduate from high school would be beyond him and that he didn't even think that would be possible."

Emotional/physiological experiences with teachers on an academic and personal level can raise one's self-efficacy, but unpleasant events involving failure in performing a task or failure on a test and unpleasant socio-economic factors can lower one's self-efficacy. Few critical incidents were identified by interviewees, and those mentioned focused on surviving and learning from negative experiences involving failure, a lack of support on an academic and personal level, and socio-economic conditions that lowered self-efficacy. The participants who moved from school to school in their early years as students reflected on their negative experience at an emotional level. Their experiences with urban schools, bullying, disintegrated family, and low economic status at home were central to low self-efficacy.

In summary, mastery experiences contributed significantly to the pre-service teachers' levels of self-efficacy in science. The past experiences of the pre-service elementary teachers also revealed that social persuasion and vicarious experiences enhanced their self-efficacy beliefs towards science rather than lowering it, stimulating their desire to teach in schools. Emotional/physiological experiences had lowered the self-efficacy beliefs of some interviewees and raised self-efficacy beliefs for others.

Research Question 4 was aimed at understanding the impact of pre-service teachers' past experiences with science in their K-12 student years (a) on their present beliefs and (b) on their future beliefs in science teaching. This study gathered information on the pre-service teachers' past science experiences by analyzing the various sources of self-efficacy that may have shaped their beliefs towards science teaching today and in the future.

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All 12 participants in this study attributed their self- efficacy beliefs toward science and science teaching to their past school science experiences. Various reasons existed as to why participants perceived their K-12 science experiences as positive and negative. The participants who scored high on the STEBI-B survey were exposed to positive science related experiences and were hence confident to teach science in elementary classrooms in the future. Their self-efficacy levels were relatively high. On the other hand, students with low scores on the STEBI-B survey had more negative experience in their K-12 years and were less confident. VB had no positive experience with science in her K-12 years. This fed her dislike of science and lowered her self-efficacy towards teaching science in future classrooms. Earlier researchers such as Howitt (2007), Jarett (1999), Mullhound and Wallace (1996), and Palmer (2005) have also found that negative experiences with science in K-12 years lower self- efficacy.

For this group of pre-service elementary teachers, all of the negative critical incidents occurred during the middle and high school years. In interviews, participants attributed this to a lack of understanding of the science concepts and lack of attention from the teachers in their science classrooms. Various other reasons that may have impacted teachers' beliefs about science included: limited science in elementary school and teacher-centered and textbook-based learning. As students, these pre-service teachers began to view science as uninteresting. They learned science through memorization of facts only to get through their examinations.

The present science methods course, SCE 3310, includes many hands-on activities that may be helpful in improving the self-efficacy of some of the participants

who had past negative mastery experience with science. Earlier studies on prospective elementary teachers (Watters & Ginns, 2000) have reported the importance of science methods courses for prospective teachers in raising self-efficacy toward science teaching. As evidenced in a review of interview transcripts, participants, all of whom were enrolled in SCE 3310, emphasized the importance of hands-on learning and discussions about their attitudes towards science. Some of the participants who had low self-efficacy about science were excited to be learning science-related hands-on activities in SCE3310 and were excited to apply them as future teachers of science. The participants were motivated by their professor's talent to compose songs as a part of science instruction. The participants' vicarious experiences with their professor appeared to be very positive in enhancing their self-efficacy in science.

Another important component of this study was teacher knowledge and qualifications. Half (9, 50%) of the participants disliked science at some point in their K-12 years because of their science teachers and methods of instruction. The common repetitive words used by the participants for their negative high school chemistry experience were "hard" or "awful" or "crazy." One of the participants (BA) was unable to comprehend what the teacher taught, and two others (BR and TB) could not connect to Chemistry and the Chemistry teacher at all. In a national survey (2000) conducted by Horizon Research on the status of high school chemistry teaching, it was found that 50% of the Chemistry teachers were in dire need of professional development related to teaching Chemistry through inquiry. Of those surveyed, 50% needed help in understanding student thinking and deepening their content knowledge.

The emotional component of this study was related to need-based instruction and support. Almost all the interviewed participants expressed their desire to be compassionate, caring and supportive teachers who would go out of their way to help students who needed support. This often emerged because of an individual's past negative experience. EG believed that if she had been given attention and support by her elementary teacher, she could have done much better in school. BA, who was a Latin American, believed that ESOL students should get extra support from their teachers to keep up with their fellow students. This participant believed strongly that the traumatic events such as divorce, fights, and hunger render students unable to focus when in school, and that the lack of teacher attention makes the situation worse. As Gay (2000) mentioned, "Caring is a foundational pillar of effective teaching and learning, [and] the lack of it produces inequities in educational opportunities and achievement outcomes for ethnically different students" (p. 62). BA believed that she was denied that invaluable support and that this impacted her motivation and self-esteem. Earlier researchers have established that caring teachers can be valuable motivators (Cox & Williams,2008; Ingersoll & Smith, 2003; Klemm & Connell, 2004) and will be able to embrace the students for whom they are responsible. Almost all the interviewees believed that being compassionate, caring, and motivational were primary roles of a teacher, especially in elementary schools where the sensitive nature of little children needed to be considered.

The participants with low scores on the STEBI-B survey were uncomfortable, anxious, and lacked confidence with teaching science in the future. These participants were apprehensive because of the negative experiences with science in their K-12 years

as a result of experiencing a traditional text-book based science instruction and lack of hands-on science related activities during their schooling. The pre-service teachers who scored high on their survey (STEBI-B) were highly confident because their past experiences with science in K-12 years were activity based and fun-filled. They had teachers who helped them understand science concepts better through inquiry and supported them to be achievers. The high scorers, TW, JN, HR, and AS were positive in their self-efficacy beliefs towards science teaching and were confident that they could make science teaching more activity-based and interesting due to their positive experiences in the past. However the participants with low scores did lack confidence towards science teaching due to their past experiences. They, however, were confident that they could, in the future, teach science using more indoor and outdoor activities related to science, thereby making science a likable subject. The reason for their optimism was the present science methods course, in which they were enrolled. This course encouraged hands-on learning experiences in science and boosted their confidence in their science teaching abilities.

Limitations

There were several limitations associated with the study.

1. The data were self-reported; thus, the accuracy of the data may have been limited by participants' ability to recall accurately events or incidents. Also, the efficiency of the data being reported may have been compromised by participants' inability to recognize, reflect on, and verbalize their past

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experiences (Nisbett & Wilson, 1977). Some individuals may also, in recalling past experiences, have modified their recollections to meet what they believed to be present needs of the researcher.

2. This study was limited to a sample size of 108 students in Phase I of the study and the 12 students selected to participate in Phase II, the qualitative portion of the study. Thus, though the study may offer valuable information, it results cannot be generalized beyond this population.

3. Time presented a limitation in this study. Students were on tight schedules, and a single interview was conducted with each of the 12 pre-service teachers. It would have been helpful to be able to revisit some issues for information missed in the original interview.

Implications for Practice

This study addressed a lack of ample research on pre-service elementary teachers' self-efficacy beliefs using the Flanagan's (1954) critical incident technique. The findings of this study paved the way for important suggestions for teachers' classroom practice.

Pre-service teachers' self-efficacy beliefs towards science can impact student learning in science classrooms. Engaging students in inquiry based science learning and communicating with students using the language of science can improve student achievement in science. Pre-service teachers should be provided with appropriate training available to prepare them to teach students based on the requirements of the National Science Education Standards.

Researchers have claimed the importance of language learning in science (Shanahan & Shea, 2012; Wellington et al., 2001). One of the findings in this study revealed negative experiences with science because English was a second language of at least one participant, and understanding the language of science was difficult, particularly given that their science instruction was teacher-centered and lacked student-teacher interaction and support. Hence, adding language learning in science education curriculum is recommended.

Researchers have also attributed students' success and increased self-efficacy to a caring and supportive teacher (Cone, 2012; Furrer & Skinner, 2003; Gutman, & Midgley, 2000). Teacher education preparation programs should be aware of the potential impact they can have on their students and assist them as they persist, accomplish their goals, and build confidence regarding their teaching abilities in science.

Preparing pre-service elementary teachers to accommodate themselves to diverse cultures, different study habits of students and need-based instruction is also recommended. Based on the requirements of the multicultural population in most schools of the United States, pre-service elementary education curriculum should be revisited and modified as needed based on the requirements of the National Science Education Standards. Modifications should address the time allotted to teach science in elementary schools.

In this study, the science methods course was viewed by interviewees as particularly valuable and appeared to have the potential to influence beliefs and increase self-efficacy of pre-service teachers. Institutions offering such courses should take great

care in structuring these valuable courses so as to address the nine assertions presented in this study and thereby strengthen the beliefs and self-efficacy of pre-service teachers.

<u>Recommendations for Future Research</u>

1. The qualitative phase of this study was limited to 12 participants, 10 of which were White females. Another study could include a larger population which would be more diverse. The study could focus on students' experiences with science in K-12 classrooms with white teachers and teachers of color and its impact on their beliefs and self-efficacy.

2. This study utilized a small population of a southeastern university in the United States. A study could be conducted on a larger scale, involving multiple universities, so as to gather more information in regard to pre-service elementary teachers' past self-efficacy beliefs and their impact on current levels of confidence in teaching science.

3. Nine assertions were put forth in conducting this research. These assertions provide a wealth of areas which could be investigated further in regard to pre-service teachers' beliefs and self-efficacy. Increased attention to beliefs, confidence levels, and attitudes of prospective teachers in teaching science and technology could result in improvements that might alter and improve science educational practices.

Summary

This study was conducted to examine the impact of prior science experiences on the beliefs and the self-efficacy of pre-service elementary teachers. This is important because undergraduate students often come into their preparation programs with tangible beliefs about teaching which sometimes act as barriers to their being receptive to modifying their views about teacher instruction (Richardson, 1996). The themes and supported assertions that emerged from interview data in this study provide direction for both practitioners and researchers. The themes illuminate experiences and relationships that can contribute either positively or negatively to the beliefs and self-efficacy of prospective teachers. The themes and assertions that emerged recognize the importance of qualified and knowledgeable teachers who care for and interact with their students, who utilize student-centered activities and mastery learning in their classrooms, and who continually strive to improve science instruction.

Though one would wish that all teacher education students would possess high levels of self-efficacy and hold strong beliefs about science instruction based on positive prior experiences, this is not likely to occur. Thus, it remains for teacher preparation programs to be attentive to the themes and the assertions put forth in this research in order to positively influence the beliefs and self-efficacy of future teachers of science who will, in turn, influence the beliefs of their students. This is possible only if policy makers and school administrators provide needed professional development programs, resources, and allocate sufficient time for science instruction in the elementary curricula. These actions will give pre-service teachers opportunities to have experiences that will

help them succeed in their profession as great teachers, thereby having a lasting impact on student achievement in a positive way and indirectly influence their self- efficacy beliefs towards science teaching in future elementary classrooms.

APPENDIX A
SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT-PRE-SERVICE
(STEBI-B)

Enochs, L. G., & Riggs, I. M. (1990)
(Pre-service Science Teaching Efficacy Belief Instrument)

Please provide the demographic information below for further communication. The information provided will be kept confidential.

Email-ID

Date

Gender

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.
SA = STRONGLY AGREE
A = AGREE
UN = UNCERTAIN
D = DISAGREE
SD = STRONGLY DISAGREE.

Question	Scale of Importance
1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort .	SA A UN D SD
2. I will continually find better ways to teach science.	SA A UN D SD
3. Even if I try very hard, I will not teach science as well as I will most subjects.	SA A UN D SD
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD .
5. I know the steps necessary to teach science concepts effectively.	SA A UN D SD.
6. I will not be very effective in monitoring science experiments	SA A UN D SD

7. If students are underachieving in science, it is most likely due to ineffective science teachi*ng*	SA A UN D SD
8. I will generally teach science ineffectively	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching	SA A UN D SD.
10. The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD.
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD.
12. I understand science concepts well enough to be effective in teaching elementary science	SA A UN D SD
13. Increased effort in science teaching produces little change in some students' science achievement	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher	SA A UN D SD
17. I will find it difficult to explain to students why science experiments work.	SA A UN D SD

18. I will typically be able to answer students' science questions.	SA A UN D SD
19. I wonder if I will have the necessary skills to teach science	SA A UN D SD
20. Given a choice, I will not invite the principal to evaluate my science teaching	SA A UN D SD
21. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better.	SA A UN D SD
22. When teaching science, I will usually welcome student questions.	SA A UN D SD
23. I do not know what to do to turn students on to science.	SA A UN D SD

THANK YOU

APPENDIX B
CRITICAL INCIDENT TECHNIQUE INTERVIEW PROTOCOL

Teacher's Belief Questionnaire
Based on Critical Incident Technique
(Flanagan, 1954)

Thank you for agreeing to participate in this interview and contributing to my research.

My name is Meera Ravikumar and the purpose of the interview is to gather information regarding the K-12 experiences of prospective elementary teachers. Your responses (recorded with permission) will remain confidential. There are no correct or incorrect answers.

Let's begin with your background information:

1. Tell me where you are from?

2. Your historical background?

3. How did you get to this institution?

4. What is your current status as a student?

5. When do you anticipate to do your internship?

6. What grade will you be teaching in future?

7. What are you looking forward to in your internship?

Let's discuss your experiences as a K-12 student:

1) Describe an incident or experience involving a teacher or an activity that stands out in your memory?

   (If the answer does not involve a science experience (probe) "what about your science experience in K-12)

2) Describe what the teacher said or did. Describe what you thought, said, and did in response.

3) In what grade did this occur?

4) Looking back at this experience today, how does it affect you and how you think about yourself?

5) Describe how you believe this experience will affect your belief as a future teacher of science?

APPENDIX C
INSTITUTIONAL REVIEW BOARD APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
           FWA00000351, IRB00001138

To: **Meera Ravikumar**

Date: **January 14, 2013**

Dear Researcher:

On 1/14/2013, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Pre-Service Elementary Teachers' Self Efficacy Beliefs towards science using Critical Incident Technique: A Case Study approach.
Investigator:	Meera Ravikumar
IRB Number:	SBE-12-08985
Funding Agency:	
Grant Title:	
Research ID:	SBE-12-08985

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 01/14/2013 01:38:43 PM EST

Joanne Muratori

IRB Coordinator

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APPENDIX D
PARTICIPANT EMAIL COMMUNICATION

Hi,

My name is Meera Ravikumar and as I had mentioned two weeks ago, regarding the interviews, you have been randomly selected for the interview. Would you be interested in participating for the interview? If yes, please send me a reply.

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