AN ABSTRACT OF THE DISSERTATION OF

Catherine J. Perkins for the degree of Doctor of Philosophy in Science Education presented on September, 17, 2007.
Title: Toward Making the Invisible Visible: Studying Science Teaching Self-Efficacy Beliefs.

Abstract approved:

Larry G. Enochs

This dissertation consists of two articles to be submitted for publication. The first, a literature review, makes visible common influences on science teaching self-efficacy beliefs and also points to potentially invisible validation concerns regarding the instrument used. The second investigates the participants' invisible science teaching self-efficacy beliefs and, through the use of a more focused interview, makes those beliefs visible.

Science teaching self-efficacy beliefs are science teachers' perceptions of their abilities to teach science effectively. The construct "teaching self-efficacy" originated in social cognitive theory (Bandura, 1977). The first article reviews the mixed results from teaching self-efficacy research in science contexts. The review focuses upon factors that facilitate or inhibit the development of self-efficacy beliefs among science teachers across stages of their careers. Although many studies of science teaching self-efficacy beliefs have utilized the Science Teaching Efficacy Belief Instrument - STEBI (Enochs & Riggs, 1990; Riggs & Enochs, 1990), this review also includes non-STEBI studies in order to represent diverse lines of research methodology. The review's findings indicate that antecedent factors such as science activities in and out of school, teacher preparation, science teaching experiences and supportive job contexts are significant influences on the development of science teaching self-efficacy beliefs. The review also indicates that the

majority of these studies are short term and rely on a single STEBI administration with the collection of antecedent/demographic and/or interview data.

The second article documents a study that responded to the above literature review findings. This study utilized multiple STEBI administrations during the preservice and beginning year of teaching for two science teachers. Rather than general questions, these participants were asked item specific, yet open-ended, questions to determine what events or experiences the participants felt influenced their survey answers. This methodological approach was chosen to add clarity to the STEBI scores and to add another layer in the ongoing process of instrument validation. Unlike some studies in science teaching self-efficacy, both participants' STEBI scores continued to increase as they transitioned from preservice to beginning teachers. The participant responses to the focused interview probes also validated their STEBI scores 77% of the time.

Toward Making the Invisible Visible: Studying Science Teaching Self-Efficacy Beliefs

by
Catherine J. Perkins

A DISSERTATION

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APPROVED:

Major Professor, representing Science Education

Chair of the Department of Science and Mathematics Education

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Catherine J. Perkins, Author

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To Dr. Larry Enochs for mentioning he had a database… without his guidance and dedication this dissertation would have remained an unattained goal

To Dr. Emily van Zee who saw and believed

CONTRIBUTION OF AUTHORS

Larry Enochs designed the survey instrument many years ago, administered it during the preservice phase of the project, and supervised the study.

Catherine Perkins administered the instrument during the inservice phase of the project, interviewed the participants, analyzed the data, and wrote the manuscript.

Emily van Zee assisted with design of the study and editing the manuscript.

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DEDICATION

To my husband: a better partner I could not have found

To my children: thank you for allowing me to take the time to pursue this goal
and close my office door

To my parents: who taught me that questioning and change
are often valuable and viable Life pursuits

To my friends: who often shook their heads and supported me nonetheless

To Larry and Emily: who gave me the opportunity and their invaluable guidance

Chapter 1: General Introduction

Science teaching self-efficacy beliefs are teachers' perceptions of their abilities to teach science effectively. The construct "teaching self-efficacy beliefs" originated in social cognitive theory (Bandura, 1977). Beliefs are part of the foundation upon which behaviors are based. This dissertation considers beliefs from a philosophical perspective: beliefs are propositions that do not require a truth condition and that are accepted as true by the individual holding the belief (Green, 1971). As defined in social cognitive theory, individuals are motivated to perform an action if they are confident that they can perform that action successfully (Bandura, 1977). These self-efficacy beliefs are future-oriented judgments about capabilities to organize and execute the courses of action required to produce given attainments in specific situations or contexts (Bandura, 1997). Bandura (1977) identified four sources that inform an individual's sense of self-efficacy: 1) mastery experiences – an individual's past successes and failures; 2) vicarious experience – skill in question is modeled by someone considered competent by and comparable to the individual; 3) verbal/social persuasion - encouragement received from a knowledgeable source and 4) physiological and affective states – somatic information conveyed by physiological and emotional arousal.

According to Bandura's theory, teaching self-efficacy is a domain specific construct which focuses on the teachers' perceptions of their ability to: "organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran, Hoy, & Hoy, 1998, p. 233). Self-efficacy judgments are beliefs about one's own capabilities, not necessarily accurate assessments of those capabilities. Thus, science teaching self-efficacy beliefs are teachers' perceptions of their abilities to teach science effectively, which may or may not be the case depending on the person and the teaching situation.

Historically and educationally, teachers' beliefs toward science have been found to influence their teaching practices (Moore & Watson, 1999; Stevens & Wenner, 1996), as well as teachers' understanding of science content (Atwood & Atwood, 1996; Trundle, Atwood, & Christopher, 2002). One teacher characteristic that has been consistently related to student achievement (Armor et al., 1976), implementation of innovation (e.g., Ghaith & Yaghi, 1997)) and commitment to teaching (e.g., Ware & Kitsantas, 2007) is a teacher's teaching efficacy beliefs.

Researchers, however, have found mixed results in studies investigating the development of teaching self-efficacy in preservice teachers. Soodak and Podell (1997), for example, saw a decrease and Woolfolk Hoy and Spero (2005) saw an increase in teaching self-efficacy beliefs at different preservice program stages. Both of these studies used a generalized teaching self-efficacy instrument developed by Gibson & Dembo (1984). Mixed results also have been found with a subject specific science teaching self-efficacy instrument – the STEBI - developed by Enochs & Riggs (1990). Research reports include increases in preservice teachers' science teaching self-efficacy beliefs (e.g., Cantrell, Young, & Moore, 2003) as well as decreases (e.g., Ginns & Watters, 1999).

This dissertation consists of two articles to be submitted for publication. The first, a literature review, investigates the mixed results from teaching self-efficacy research in science contexts. The review focuses upon factors that facilitate or inhibit the development of self-efficacy beliefs among science teachers across stages of their careers. It makes visible common sources of influences on science teaching self-efficacy beliefs and also points to potentially invisible validation concerns regarding the instrument used. The second article documents a study that responded to the above literature review findings. This study utilized multiple STEBI administrations during the preservice and beginning year of teaching for two science teachers. Rather than general questions, these participants were asked item specific, yet open-ended, questions to determine what events or experiences the participants felt influenced their survey answers. This methodological approach was chosen to add clarity to the STEBI scores and to add another layer in the ongoing process of instrument validation.

SCIENCE TEACHING SELF-EFFICACY BELIEFS: A REVIEW OF THE LITERATURE

Catherine J. Perkins
Larry G. Enochs
Emily van Zee

Journal of Science Teacher Education
233 Springer Street
New York, NY 10013
To be submitted

Science and Mathematics Education
Oregon State University, 239 Weniger Hall, Corvallis, Oregon 97331-6508
T 541-737-1305 | **F** 541-737-1817 | www.oregonstate.edu/dept/sci_mth_education

September 17, 2007

Charlene M. Czerniak, Editor-in-Chief
University of Toledo, Ohio

Dear Dr. Czerniak:

Enclosed is a manuscript submitted for publication in the *Journal of Science Teacher Education* entitled "Science Teaching Self-Efficacy Beliefs: A Review of the Literature."

Our intent during the development of this manuscript was to provide a presentation as comprehensive and informative as possible. The mixed results in the science teacher self-efficacy literature point to the necessity of reviewing the research to identify factors that facilitate or inhibit the development of self-efficacy beliefs among science teachers across stages of their careers. Many studies of science teaching self-efficacy beliefs have utilized the Science Teaching Efficacy Belief Instrument (Enochs & Riggs, 1990; Riggs & Enochs, 1990). In order to review diverse lines of research methodology, this paper also includes qualitative studies and quantitative studies in which non STEBI instruments were used.

Any consideration you may give concerning this manuscript will be appreciated.

Sincerely,

Catherine J. Perkins

Please address all correspondence as follows:
Catherine J. Perkins
Science and Mathematics Education Department
239 Weniger Hall
Oregon State University
Corvallis, OR 97331
Email: cperkins@archdpdx.org
Cc Larry G Enochs

Chapter 2: Science Teaching Self-Efficacy Beliefs: A Review of the Literature

The United States is currently experiencing relatively low student achievement scores (National Assessment of Educational Progress, 1990, 2006; National Commission on Excellence in Education, 1983; Third International Mathematics and Science Study, 1996) and a changing, globally competitive workforce (Schmidt, 1997; Wise & Leibbrand, 2000). In response, many groups have created reform policies regarding classroom curricula and practice (American Association for the Advancement of Science, 1989, 1993; American Psychological Association, 1997; National Research Council, 1996). These reform documents emphasize science learning experiences that focus on developing problem-solving and critical-thinking skills. In classroom settings, teachers are viewed as facilitators who support students' inquiries by posing questions and directing their processing and exchange of scientific ideas.

Although the educational benefit of these practices to students' learning is realized, their actual implementation in schools is limited (Hiebert & Stigler, 2000; Judson & Sawada, 2001b; Pasley, Weiss, Shimkus, & Smith, 2004; Schepige, Morrell, & Wainwright, 2004). The likelihood of seeing reform based science instruction is even less likely considering the loss of almost half of the beginning teachers within the first five years of teaching, with science and mathematics teachers the most likely to leave in comparison to other teachers (Guarino, 2006; Henke, 2001; Liu, 2007).

Teachers' beliefs toward science have been found to influence their teaching practices (Moore & Watson, 1999; Stevens & Wenner, 1996), as well as teachers' understanding of science content (Atwood & Atwood, 1996; Trundle et al., 2002). Although policymakers and the public hope for solutions, one teacher characteristic that has been consistently related to student achievement ((Armor et al., 1976), $r = 0.37$. $p < 0.05$) implementation of innovation ((e.g., Ghaith & Yaghi, 1997), $r = 0.62$. $p < 0.05$) and commitment teaching ((e.g., Ware & Kitsantas, 2007) $r = 0.37$. $p < 0.01$) is a teacher's teaching efficacy beliefs.

Teaching self-efficacy efficacy beliefs are defined as teachers' beliefs in their "ability to bring about change in their students" (Soodak & Podell, 1997, p. 215). Researchers have found mixed results in studies investigating the development of teaching self-efficacy in preservice teachers. Soodak and Podell (1997), for example, saw a decrease and Woolfolk Hoy and Spero (2005) saw an increase in teaching self-efficacy beliefs at different preservice program stages. Both of these studies used a generalized teaching self-efficacy instrument developed by Gibson & Dembo (1984). Mixed results also have been found with a subject specific science teaching self-efficacy instrument developed by Enochs & Riggs (1990). Research reports include increases in preservice teachers' science teaching self-efficacy beliefs (e.g., Cantrell et al., 2003) as well as decreases (e.g., Ginns & Watters, 1999).

The mixed results in the science teacher self-efficacy literature point to the necessity of investigating the research regarding the development of teaching self-efficacy beliefs among preservice teachers and into their subsequent years. The mixed results could also be due to the varied ways researchers have documented and validated their findings. This article provides a conceptual and methodological review (Kennedy, 2007) of the science teaching self-efficacy research to identify factors that facilitate or inhibit the development of self-efficacy beliefs among science teachers across stages of their careers. The following questions frame this review:

(a) What science teaching efficacy beliefs do preservice science teachers have at various points of time in during their teaching preparation program?
(b) How do science teaching efficacy beliefs change during their subsequent years of teaching?
(c) To what are changes in personal science teaching efficacy attributed?
(d) How do researchers seek validation of their science teaching self-efficacy findings?

Self-Efficacy Beliefs: Key Concepts

Beliefs are part of the foundation upon which behaviors are based. This review considers beliefs from a philosophical perspective: beliefs are propositions that do not require a truth condition and that are accepted as true by the individual holding the belief

(Green, 1971). As defined in social cognitive theory, individuals are motivated to perform an action if they are confident that they can perform that action successfully (Bandura, 1977). These self-efficacy beliefs are future-oriented judgments about capabilities to organize and execute the courses of action required to produce given attainments in specific situations or contexts (Bandura, 1997). Bandura (1977) identified four sources that inform an individual's sense of self-efficacy: 1) mastery experiences – an individual's past successes and failures; 2) vicarious experience – skill in question is modeled by someone considered competent by and comparable to the individual; 3) verbal/social persuasion - encouragement received from a knowledgeable source and 4) physiological and affective states – somatic information conveyed by physiological and emotional arousal.

The first instrument to measure teacher self-efficacy originated in the RAND study that evaluated 100 Title III projects associated with the 1965 Elementary and Secondary Education Act (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977). These researchers used two efficacy items and investigated teachers' beliefs concerning aspects the teachers felt they could control (or at least strongly influence) in their school and their students' achievement and motivation. The results pointed to teaching self-efficacy beliefs as the most important factor when it came to teachers' promoting their students' learning and motivation. These results were confirmed in studies on implementation of new school or district programs (Ashton & Webb, 1986; McLaughlin & Marsh, 1978), Gibson and Dembo (1984) extended the research and found that self-efficacy was comprised of two separate and uncorrelated factors: factors they called personal teaching efficacy and teaching outcome expectancy. However, efficacy is a situation and context specific construct (Bandura, 1981). Teaching self-efficacy is a domain specific construct which focuses on the teachers' perceptions of their ability to: "organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran et al., 1998, p. 233). Self-efficacy judgments are beliefs about one's own capabilities, not necessarily accurate assessments of those capabilities. Thus, science teaching self-efficacy beliefs are science teachers' perceptions of their abilities to teach science effectively, which may or may not be the case depending on the person and the teaching situation. Teachers may feel quite efficacious concerning some classes and feel quite the opposite in other content areas. A general efficacy instrument, like Gibson and Dembo's, proved to be ineffectual at capturing these content specific situations. Modifications of the Gibson & Dembo instrument were therefore made within particular content areas.

The Science Teaching Efficacy Belief Instrument (STEBI A) was initially created by Riggs & Enochs (1990). Through a quantitative study with preservice elementary teachers, these researchers, confirmed that the personal science teaching efficacy and teaching outcome expectancy constructs were distinct, valid and reliable The STEBI A scores represented elementary teachers actual beliefs about their ability to teach science: "Item 2: I am continually finding better ways to teach science" (Riggs & Enochs, p. 636). Enochs & Riggs continued to add to the efficacy research base and developed a similar instrument (the STEBI B) to measure the science teaching self-efficacy beliefs of preservice teachers based on their anticipated beliefs about their ability to teach science: "Item 2: I will continually find better ways to teach science" (Enochs & Riggs, 1990, p. 711). Widely used in subsequent years, the STEBI has been adapted into a chemistry form (Rubeck & Enochs, 1991) and a mathematics form (Enochs, Smith, & Huinker, 2000). The STEBI surveys used in this study can be found in the Appendices.

One aspect that makes teaching self-efficacy so powerful is its cyclical nature (Tschannen-Moran et al., 1998):

> the proficiency of a performance creates a new… experience, which provides new information that will be processed to shape future efficacy beliefs. Greater efficacy leads to greater effort and persistence, which leads to better performance, which in turn leads to greater efficacy. The reverse is also true. Lower efficacy leads to less effort and giving up easily, which leads to poor teaching outcomes, which then produce decreased efficacy. (p. 233)

A completed teaching performance that was accomplished with a level of effort and persistence influenced by the teacher's sense of efficacy becomes the past and a source of future efficacy beliefs. Preservice teachers, because of their newness to the teaching profession, may have limited experiences. Bandura (1977) postulated and research has confirmed that self-efficacy is most malleable in the preservice years (Housego, 1992; Hoy & Woolfolk, 1990). Research has also confirmed that once self-efficacy beliefs are established they are resistant to change (Henson, 2002).

Methodology

Selection of Studies for Review

Seven electronic databases were reviewed in the social sciences with the search terms “science teach*” and “self-efficacy” (see Figure 1. on page 30). The truncation symbol “*” was used to find possible studies that looked at science teachers as well as science teaching. The databases were Academic Search Premier, ERIC, Professional Development Collection, PsycARTICLES, PsycINFO, SocINDEX with Full Text and Web of Science. In databases that utilized searchable fields, the term “self-efficacy” was used as a subject heading term that described the document’s content. Also included were referrals by researchers active in the field of science teaching self-efficacy.

Only studies that were conducted with preservice and inservice science teachers and investigated the teaching self-efficacy beliefs of those teachers were reviewed. Only research from peer reviewed journals was reviewed. Dissertation abstracts were not reviewed. The search terms “science teach*” and “self-efficacy” resulted in a total of 53 references. All of the abstracts were read to determine whether the authors were investigating science teaching self-efficacy beliefs. Articles focused on the science self-efficacy beliefs of children and college majors or provided critical perspectives on self-efficacy or self-efficacy instruments were not included. Articles not written in English and published prior to Bandura’s first article dealing with self-efficacy beliefs (Bandura, 1977) were not included. This next level of analysis identified 41 articles.

Of the 41 articles examined for this literature review, 32 utilized the same instrument: the Science Teaching Efficacy Beliefs Instrument – the STEBI (Enochs & Riggs, 1990; Riggs & Enochs, 1990). This article reviews eight of these STEBI studies. These were chosen based on their citation frequency as determined by Science Citation Index Expanded, Social Sciences Citation Index and Google Scholar and on their individuality in terms of how they utilized the STEBI in conjunction with other data sources. This review also identified studies, both qualitative and quantitative, in which non STEBI instruments were used. The inclusion of four non-STEBI studies brings diverse lines of research methodology together to represent what has been done so far. In doing so, the field of science teaching self-efficacy research was made to look more diverse than it really is. It should be recognized that this review is a modest synthesis of current education research that is informed by and informs science teaching self-efficacy. The Appendix (p. 37) includes information for each of the selected studies: authors, date of publication, method, purpose of the study, participants, and the study aspect(s) which influenced the study's inclusion in this literature review.

Organization of the Review

The findings of the review are presented in the following sections. The first section summarize the levels and changes in science teaching efficacy beliefs and their reported attributes during the teaching preparation program. The second section utilizes a similar focus but shifts to changes in and attributes of personal science teaching efficacy in the subsequent years of teaching. A conclusion section discusses design and methodological issues and areas of further research in the area of science teaching self-efficacy beliefs.

Findings

Science Teaching Self-Efficacy Beliefs During the Teaching Preparation Program

Antecedents

Preservice participants' science teaching self-efficacy beliefs are significantly related to their antecedent factors. Ramey-Gassert, Shroyer, and Staver (1996) describe antecedent factors related to science teaching efficacy as science activities in and out of school, teacher preparation, and science teaching experiences. Even though preservice teachers have been accepted into a college, their experiences as science students seem to be related to their science teaching self-efficacy beliefs. Enochs, Scharmann & Riggs (1995) investigated the possibility of relationships among 71 preservice elementary teacher's antecedents and science teaching self-efficacy beliefs using the STEBI B (Cronbach alpha reliability coefficient of .85 for these participants). Pearson product-moment correlations were generated and science teaching self-efficacy beliefs were found to be significantly and negatively related to the years of high school science taken (r = -0.22, p< .05) and to the number of college science courses (r = -0.24, p< .05).

Conducting a more qualitative study, Tosun (2002) utilized the STEBI to provide interview prompts for his investigation of the impact of prior experiences in science courses at the high school and college levels. Participants for this study were 44 preservice students enrolled in an elementary methods course. They broken into groups based on their self-reported science achievement. The high and low science achievement groups both reported a dislike towards science and used overwhelmingly negative descriptors in describing their past science experiences. Most of the student experience was based in biology.

Cantrell, Young, & Moore (2003) also investigated the antecedents of preservice elementary teachers' science teaching self-efficacy beliefs, although they focused on the interplay of various factors such as gender, and science teaching time as well as prior and current science experiences. They utilized the STEBI B (Cronbach's alpha reliability coefficient for the study's sample was .87) in conjunction with a demographic questionnaire to document the teaching efficacy beliefs of one cohort of elementary preservice teachers at three stages of their program. Cantrell, Young, & Moore (2003) differed from the Enochs, Scharmann & Riggs (1995) study by also asking their participants to indicate whether or not they had participated in extracurricular high school science activities such as science fairs or science clubs or had been mentored by a scientist in some way. They also asked the participants to report the amount of time they spent teaching science per week in elementary school classrooms. Means were compared using ANOVAs, and significant effects were followed up by effect size as a measure of the magnitude and practical difference between the means. Cantrell, Young, & Moore (2003) found that science teaching self-efficacy beliefs were significantly and positively related to: 1) gender (males' were significantly higher than females), 2) participation in extracurricular high school science activities, 3) number of years and classes of high school science and 4) teaching science to children for more than three hours per week.

The number of years of high school science provided conflicting results for the researchers in this section. Although Cantrell, Young, & Moore (2003) found significant positive interactions with science teaching self-efficacy beliefs, Enochs, Scharmann & Riggs (1995) reported a significantly negatively correlation. This difference could be the result of differing samples. This difference is also possibly due to Enochs, Scharmann & Riggs sample's limited or non-existent exposure to reform based science practices as high school students – the National Research Council's science reform document came out the year after the study (National Research Council, 1996). With high school antecedent experiences originating in a traditional/lecture setting, their sample's less than confident response to teaching activity based science might have been warranted.

Field Experiences

Both studies recommended early experience of teaching prior to the student teaching experience. For Enochs, Scharmann & Riggs (1995) this recommendation was suggested to counteract the apparent negative relationship of college subject matter coursework to science teaching self-efficacy beliefs. More opportunities for preservice teachers to gain further insights into the value of social learning models (i.e., cooperative and collaborative learning) might lessen the influence of traditionally lecture based coursework experiences. Providing these opportunities both within a methods class and in the actual classroom setting might reinforce a more humanistic classroom management activity-based teaching style. Cantrell, Young, & Moore (2003) also recommended early experiences based on their striking finding of the ceiling effect that occurred during the methods phases. As long as methods students were performing three hours of science teaching every week, their self-efficacy beliefs scores were comparable to those of student teachers.

In actually reporting on preservice experiences, Mulholland & Wallace (2001) did not find positive and educative role models. These researchers studied an elementary preservice teacher into her first year as a novice teacher. Reflective journals, interviews and jobsite classroom observations were used to create a retrospective and chronological account, linking past events to explain the growth of the participant's self-efficacy beliefs over the period documented in the study. Mulholland & Wallace's narrative analysis was based on examining the accounts in terms of Bandura's four sources of self-efficacy. In her preservice program, this participant did not have a vicarious source for her science teaching efficacy – her cooperating teachers did not teach any science classes and instead asked the preservice participant to take over the teaching of the science lessons. She did so and although her initial attempt was a failure, she later successfully repeated the lesson during her practicum. Although lacking a role model but fuelled by the successful re-attempt, the participant persevered in achieving success towards the end of her preservice year.

Ginns & Watters (1999) reported a similar lack of support in their preservice teachers' practicum setting. As preservice teachers, all three of the participants had limited experience observing their cooperating teachers teach science – only one of the participants saw a science lesson taught by her cooperating teacher. Instead, the cooperating teachers turned over all the science instruction to the preservice teachers. As preservice teachers, the participants regularly failed in teaching science lessons effectively, but they continued to persevere, learned from their failures and, on repeating the now modified lesson, were successful. The researchers also suggested that prior background influenced the decreasing scores during the preservice phase. In one case, the decrease was less severe because the participant was very confident in her subject matter knowledge. In another, the decrease was interpreted as more dramatic because this participant's initially high self efficacy might have originated from a rote learning subject matter background which did not align with the teacher education program's delivery style.

Science Content Knowledge and Science Methods

As preservice science teachers embark on their teacher preparation program, their science teaching self-efficacy beliefs may be related to their science content knowledge. Schoon & Boone (1998) investigated erroneous and alternate science conceptions of preservice science teachers during the first few weeks of their science methods class. Studying 619 preservice elementary teachers from ten university campuses, Schoon and Boone (1998) investigated science teaching efficacy beliefs and the number and type of science alternative conceptions held by these future teachers. Alternative conceptions refer to misconceptions that may play a crucial role in learning by interfering with science comprehension. Individuals with science alternative conceptions may have great difficulty learning new material due to the faulty foundation the alternative conceptions provide. In previous work (Schoon, 1995), this researcher found preservice elementary teachers to have the same alternative conceptions as their students and that many attributed them to their own elementary school experiences. Prior to their student teaching, participants were given a survey comprised of the STEBI B (reliability for this study 0.89) and a multiple choice test for common alternative conceptions of science. Schoon and Boone (1998) thoroughly discuss and provide evidence regarding their pilot testing of the STEBI with modifications by underlining the word "<u>some</u>" and increasing the responses to a six point rating scale. It is disappointing that information concerning the reliability and development of their alternative conception test is not present in their article. The Rasch model (Rasch, 1960) was used to evaluate the survey data. Participants with the greatest number of correct science conceptions (eight or more) had significantly higher science teaching self-efficacy beliefs than those with fewer correct answers (probability of $>[t] = 0.0153$). When these researchers examined science teaching self-efficacy beliefs and the selection of alternative conceptions, however, they found no significance difference between the fewer correct alternative conceptions selected group and the science teaching self-efficacy beliefs they held and the science teaching self-efficacy beliefs held by the more correct alternative conceptions selected group. This may be due to the groups' selection of the two distracters instead of the correct answer or the alternative conception. The final significant findings discussed by the researchers are the "*specific* (italic's are Schoon and Boones)" alternative conceptions. These researchers designed their test to investigate five critical barriers that: "must be comprehended before more complex concepts can be understood" (p. 556). Schoon and Boone do not provide information as to their selection process involving the five critical barriers. Significantly lower science teaching self-efficacy beliefs was associated with participants who held the five specific (critical barrier) alternative conceptions (*p*'s ranged from 0.02 to 0.07 for the five critical items). The successful modification and reliable use of the STEBI with different universities is unique to this study and adds to the research base.

Taking up where Schoon & Boone's study ended, many researchers have sought to design teacher preparation experiences to increase preservice science teachers' science content knowledge and science teaching self-efficacy beliefs. For example, Bleicher (2006) investigated the teaching self-efficacy beliefs of preservice elementary teachers and their developing science conceptual understanding. Prior to any field experience, 70 preservice elementary teachers were enrolled in an earth science methods course which focused on instructional strategies modeled in class and hands on experimentation. The data sources included pre- and post-course administrations of the STEBI B and a science conceptual understanding test (Cronbach alpha reliability coefficients of 0.84 and 0.85); three midterms; field notes; and an instructor's journal. Students wrote weekly reflection journals in which they: 1) self-rated their confidence on a 5 point scale as a science learner and teacher, 2) wrote about their feelings concerning the science concepts and 3) wrote how they would use those concepts as future science teachers. A two tailed, paired sample *t*-test revealed significant increases in the participants' science conceptual understanding (t=3.137, p<0.001). A similar analysis and significant finding was seen for their science teaching self efficacy beliefs (t=9.003, p<0.001). Both gains were supported in journals replete with attesting reflections. The self-rated scores from the reflection journals also showed statistically significant gains in teaching confidence (week one mean = 1.2 (low confidence); week 15 mean = 4.3 (high confidence). For the course's three sections, an ANOVA was performed on the STEBI scores and resulted in no statistically significant difference in science teaching self-efficacy beliefs. Correlations were run to determine relationships between the STEBI and the science conceptual understanding test. Significant Pearson correlations were found between post conceptual understanding and post science teaching self-efficacy beliefs (r=0.312, p<0.05). The researcher stated that this correlation "indicates that the two are linked in some manner and, although not suggesting a cause and effect relationship, either may be a predictor of the other" (Bleicher, 2006, p. 179). In this study's case, higher conceptual understanding outcomes predict that preservice teachers' self-efficacy beliefs will be more positive and vice versa.

While Brand & Wilkins (2007) also focused on science content knowledge their research also stressed the teaching of science. These researchers sought to identify factors influencing preservice elementary teachers/ science teaching self-efficacy as a result of their experiences in a hands-on, constructivist science methods course. In comparing their student's' first day write-ups on their views of science, Brand & Wilkins noted anxious and negative feelings toward science, many of them based on prior experiences and their negative feelings about teaching science and mathematics. To positively influence these beliefs, Brand & Wilkins designed the course to utilize hands-on activities to connect theory with practice, whether or not the preservice teachers were participating as "students" or as "teachers." The methods course sought to provide preservice teachers with experiences where the learning was realized through their active participation in the learning environment. Data for the study originated from the open ended question: "Based on your experiences in this course, list and discuss two ideas that you feel have had the greatest impact on your beliefs about your ability to teach science" (p. 302). In looking qualitatively at the participants' reflections, Brand & Wilkins (2007) found their course to have enhanced the preservice teachers' knowledge and confidence in teaching strategies at two impact levels: 1) some felt confident in their abilities to immediately begin planning and implementing and 2) others expressed feelings that seemed to imply changes in their way of thinking and improved confidence—or less anxiety around the state of not knowing.

Both studies found preservice elementary teachers science content knowledge lacking at the beginning of their science methods courses. For Schoon & Boone (1997), science teaching self-efficacy was positively and significantly related to the number of correct science conceptions and negatively and significantly related to preservice teachers with the five critical barrier conceptions. For Bleicher (2006), higher conceptual understanding was positively and significantly related to preservice teachers' science teaching self-efficacy beliefs. Both researchers suggested the need for teacher educators to place a greater emphasis on the understanding of basic science concepts: "… novice learners with minimal prior knowledge couldn't be expected to understand and employ core concepts in their learning schema without extensive guidance" (Bleicher, 2006, p. 165).

Summary

In those studies that collected data more than once, the development of science teaching self-efficacy varied. In studies with more than three participants, science teaching self-efficacy increased as participants progressed through their teacher education program (Bleicher, 2006; Brand & Wilkins, 2007; Cantrell et al., 2003). In the two case studies reviewed, the development of science teaching self-efficacy beliefs were revealed as cyclical (Mulholland & Wallace, 2001) and or variable (e.g. 2 participants decreased, one increased: (Ginns & Watters, 1999)). Antecedents were not always good influences on their science teaching self-efficacy beliefs. The reviewed studies revealed elementary preservice science teachers to be limited in their science concept knowledge (e.g., Schoon & Boone, 1998; Bleicher, 2006). Anxiety about teaching science and negative feelings regarding science as a subject (Brand & Wilkins, 2007; Tosun, 2000) were common. The research was split in their significant findings regarding the relationship of science teaching self-efficacy beliefs to high school experiences (Cantrell et al., 2003; Enochs, Scharmann, & Riggs, 1995). Such a dichotomy was not seen in the area of field experiences with the research indicating the necessity and positive influence of teacher education program that provided gradual mastery experiences and success, especially in the area of classroom management (Cantrell et al., 2003; Enochs, Scharmann, & Riggs, 1995). Exposure to science content in methods classes and early and supportive science teaching experiences aided in the development of the participant's high science teaching self-efficacy beliefs.

Science Teaching Self-Efficacy Beliefs During the Beginning Teaching Years

Antecedents

Antecedents continued to be influential when investigating experienced elementary teachers participating in a professional development program (Ramey-Gassert, Shroyer, & Staver, 1996). These researchers used both qualitative and quantitative methods to examine the relationship between science teaching self-efficacy and antecedent experiences. The 23 participants in this 3-year study were experienced elementary classroom teachers who were interested in science, mathematics and technology and who had participated in a long-term preservice teacher education project in the central United States. Initial data collection came from multiple sources: the STEBI-A instrument (Riggs & Enochs, 1990; Cronbach alpha reliability of 0.89); Shrigley-Johnson Attitude Toward Science Scale ((Shrigley, 1974) Cronbach alpha reliability of 0.84); science teaching /preparation background questionnaires; and surveys on antecedent science experiences. The science teaching/preparation background and STEBI-A data were analyzed to identify a representative subset of the original 23 teachers and to generate pertinent, revealing questions for the development of a structured, yet open-ended set of questions for an interview protocol (Ramey-Gassert, 1993). The representative subset was comprised of 10 (9 females and 1 male) elementary teachers who were purposefully selected for in-depth interviews to allow for more thorough examination of those participants who scored consistently high, low or midrange on the STEBI-A. Interview questions followed an exploratory, qualitative approach and probed into experiences from childhood, gender role models, family/sibling interactions, involvement in outdoor activities and hobbies, teacher preparation, and professional development experiences.

Ramey-Gassert, Shroyer & Staver (1996) concluded that the development of science teaching self-efficacy beliefs were related antecedent factors: 1) science-related experiences, successful preservice teacher preparation and professional development experiences 2) internal factors: interest in science and science teaching, desire for growth and collegiality and 3) external factors: family and community support and effective contextual communication) (p. 304). Results also revealed positive correlations of science teaching self-efficacy beliefs to attitude toward science (.85, $p < .01$), educational degree level (.522, $p < .01$), choosing to teach science (.436, $p < .05$) and self-rated effectiveness in science teaching (.405, $p < .01$).

Jobsite Context

Ginns & Watters (1999) reported that the mean STEBI scores showed a general decrease spanning the preservice to midpoint of the first year; the administration of the last survey in the second year showed an upswing in the scores. In all three cases, the participants, as novice teachers, experienced a pattern similar to their preservice experiences: little science teaching help was provided, early failures were frequent, and the participants persevered. At the inservice jobsite, colleague support was present in all three locations, but did not necessarily have to be scientific in nature; positive gains were also attributed to generalized support from colleagues. Although it seemed helpful to have a supportive principal, an upswing in science teaching self-efficacy beliefs were also seen in situations where principals gave tacit or no approval. Ginns and Watters concluded that even in situations of lower science teaching self-efficacy beliefs; classroom students fueled their teacher's successful perseverance to be effective science teachers. Mentioned in preservice and novice interviews and observed in the participants' first year, the positive student response towards the learning of science was attributed as the major source of effort to improve their classroom practices and of the second year self-efficacy score recovery.

Haney, Lumpe, Czerniak, & Egan (2002) also investigated the relation between science teaching self-efficacy beliefs and the classroom practices of inservice science teachers involved in a professional development program. These researchers also went into the classroom: “to take the next needed step and qualitatively examine this belief-action relationship through observation of actual classroom practices” (p. 183). Haney, Lumpe, Czerniak, & Egan differed from the majority of the studies reviewed in that they utilized Ford’s Motivation Systems Theory (Ford, 1992). This theory proposes that two types of beliefs are necessary for personal agency: capability beliefs (comparable to Bandura’s (1977) concept of self-efficacy beliefs) and context beliefs (beliefs about how supportive an environment is to the person’s functioning). Six inservice elementary science teachers who were participating in a National Science Foundation (NSF) professional development project participated in this study. Prior to the project, all six participants completed a survey made up of: the STEBI A, the Context Beliefs About Teaching Science (CBATS) instrument (Lumpe, Haney, & Czerniak, 2000) and a demographics questionnaire. Observations were conducted by an experienced trained observer using an established, NSF approved, effective science instruction protocol. The observer also conducted pre- and post- observation interviews and was unaware of the participant’s STEBI and CBATS scores. The researchers generated participant profiles and also conducted open-ended extended interviews to provide further evidence of the teachers’ beliefs about their teaching abilities and prior/current support structures. One point of note: although the researchers provided a model of Ford’s theory, they did not provide a rationale for how the STEBI and CBATS score categories were determined. Haney, Lumpe, Czerniak, & Egan (2002) were cautious in their findings: “generally, the findings suggest that the teachers who possessed positive capabilities (self-efficacy beliefs) and context beliefs scored high in their effective classroom practices” (p. 179). For five out of the six teachers, their beliefs were valid predictors of their subsequent classroom action. The researchers are very clear this was not the case for one teacher who, although having “robust” (p. 181) STEBI and CBATS scores, had relatively low classroom performance. These researchers are to be commended for their thorough discussion of possible reasons for this anomaly and their cautious confirmation that there is a relationship between what teachers believe and what they do in the classroom.

Classroom Context

Bandura noted that self-efficacy beliefs are not a global disposition: “some situations require greater skill and more arduous performances, or carry greater risk of negative consequences, than others” (1997; p. 411). Consequently, Bandura argued that an individual’s sense of efficacy varies from situation to situation. Both of the following studies (Raudenbush, Rowan, & Cheong, 1992; Ross, Cousins, Gadalla, & Hannay, 1999) undertook to investigate teaching self-efficacy beliefs in secondary schools where almost all teachers have daily classes that can vary in size, academic level, content and grade level. Their focus was to determine if teaching self-efficacy beliefs are a context-specific rather than a generalized expectancy, and to determine if context impacted the perceived teaching efficacy beliefs both between and within teachers.

Raudenbush, Rowan, & Cheong (1992) hypothesized that if teaching self-efficacy was situated rather than global, it ought to vary within teachers (across a teacher's several assigned classes), as well as among teachers. To test their hypothesis, these researchers utilized a purposeful sample of 16 high schools in Michigan and California to guarantee diversity in terms of state policies, district resources, school organization and student composition. A final sample of 315 academic teachers (mathematics, science, social studies and English) were given a questionnaire to report their perceptions of teaching self-efficacy beliefs for each of the classes they taught and to report the various characteristics of these classes. The questionnaire also asked about the personal and professional background of the teachers and their perceptions of their school’s organization. These teachers responded to the general, single-item measure of teaching efficacy. The researchers asked teachers to respond to the question “To what extent do you feel successful in providing the kind of education you would like to provide for this class?" The responses to this 4 point Likert scale were coded as integers; mean 3.31, SD 0.71. To gain information about science teachers’ teaching self-efficacy beliefs, the researchers organized and analyzed the data by class content. To explore whether teacher efficacy was stable across class periods in a day, Raudenbush, Rowan, & Cheong used two level, hierarchical linear modeling analytical framework which resulted in two models: a within teacher model and a between teacher model. The coefficients of the predictors of the within model became the dependent variables of the between model. The researchers observed that 44% of teacher efficacy variance was predicted by within-teacher variables. One of these within variables, track-level, was related to a positive increase in a teacher's efficacy if they were teaching an academic class rather than a nonacademic class (.439 point increase, t = 8.40 which is equivalent to 0.93 standard deviation units between academic and nonacademic classes). The other large, within effect on teaching self-efficacy beliefs was the level of teacher preparation (.404 point increase, t = 7.17 which is equivalent to 0.86 standard deviation units between "very well prepared" and "less than well prepared" classes). The between teacher model, as expected, showed that teachers tended to report higher teaching self-efficacy beliefs in high-track classes (.258 point increase, t = 2.30). However, these track effects were especially pronounced for science - particularly if these teachers were assigned honors classes (.346 point increase, t = 2.34).

Ross, Cousins, Gadalla, & Hannay (1999) investigated teaching self-efficacy and the effect of teaching outside of one's area of teaching. Drawn from nine high schools in a single district, 359 experienced high school teachers completed a survey that provided information on four of the courses that the teachers would teach in the following academic year (survey was completed in June). The within teacher variables consisted of teacher self-efficacy beliefs, course track, course grade and match of the course to the teacher's specialization. The between teacher variables were gender, career experience, school experience, school leadership and teacher's subject specialization. These researchers constructed an instrument with items emphasizing teacher's knowledge of how to deliver course content, rather than content or management strategy knowledge, both of which might not vary between courses. The reliability of the five items using a 6-point Likert scale was .89. The responses to the teaching self-efficacy beliefs 6 point Likert scale item were coded as integers; mean 5.49, SD 0.61. Step wise multiple regression was used to analyze the self-administered data. For the within teacher variables, the only variable that was a significant predictor of teaching self-efficacy beliefs was the match of the course to the teacher's subject specialization. The match with teacher's subject variable accounted for 5% of variation in the pooled within and between teacher variables. Although small, the finding is significant: Ross, Cousins, Gadalla, & Haney's sample of high school teachers had higher teaching self efficacy to teach courses within their subject. In discussing their failure to capture a larger portion of the variance, these researchers pointed to the limited number of out of subject teachers and to the possibility of lower construct validity of their teacher efficacy item. The authors end their study with this compelling argument: "if an outcome variable (e.g. teaching self-efficacy) is difficult to influence, and the outcome matters, even a small change is practically important" (p.257).

Raudenbush, Rowan, & Cheong (1992) and Ross, Cousins, Gadalla, & Hannay (1999) support the theoretical claim that teaching self-efficacy beliefs varies within teachers across the different classes they teach. These studies lend support to the idea that science teaching self-efficacy beliefs is a context-specific rather than a generalized expectancy, and that context impacted perceived efficacy beliefs both between and within teachers. Both studies make a clear case as to why they dropped the variables of the teachers' backgrounds (Raudenbush, Rowan, & Cheong: gender, years teaching experience, race and prior education; Ross, Cousins, & Gadalla: gender, career experience and school experience) from their analyses: they were not significant predictors of teaching self-efficacy beliefs. In both studies, the years of experience was a general and summative question and not connected to the years of teaching a specific class, level or course. This limited exploration of the influences of teachers' background may not be the result of limited effects but of the limited wording of the questionnaire items. Rather than dismissing teacher background from the equation, utilization of more focused subject specific questions would be more informative to future studies.

Summary

In the two studies that longitudinally investigated inservice teachers, there was a general increase in science teaching self-efficacy after student teaching (Ginns & Watters, 1999; Mulholland & Wallace, 2001). These researchers hypothesized that their participants higher preservice scores may have been due to over-inflated personal or underestimated context complexity beliefs (Ginns & Watters, 1999).

Based on the studies reviewed, experiencing science as a student seems to be influential on science teaching self-efficacy beliefs levels and on choosing to become a teacher of science. When discussing K-12 experiences, participants often attributed higher science teaching self-efficacy beliefs scores to positive experiences (Ramey-Gassert et al., 1996). Teachers who had a high confidence in their ability to teach science often, however, also had negative early science experiences as children. According to the research, these individuals vowed that their students would never have those types of experience and persevered in creating positive learning experiences for their students (Ginns & Watters, 1999; Mulholland & Wallace, 2001).

Another theme in the research presented here was the potentially positive influence a supportive context during preservice field experiences and jobsite might have (Haney, Lumpe, Czerniak, & Egan, 2002). Interestingly, the support did not necessarily have to be from co – science teachers to have a positive and significant impact on inservice science teachers' self-efficacy beliefs (Ginns & Watters, 1999). Student support and the reactions from students were also attributed to higher science teaching self-efficacy levels (Ginns & Watters, 1999; Mulholland & Wallace, 2001) as were the positive and significant influence from administrative support (Haney et al., 2002; Ramey-Gassert et al., 1996).

Only two studies (Raudenbush, Rowan, & Cheong, 1992; Ross et al., 1999) were found that investigated science teaching self-efficacy at the high school level and both were included in this literature review. Both found science teachers' efficacy to be directly connected with the level of preparation they felt going into the science classroom. They also both published significant correlations between high school science teacher's science teaching self efficacy and the level or track of science class they taught.

Design and Methodological Issues

The majority of educational research dealing with teaching self-efficacy beliefs relies on the administration of an instrument and the collection of antecedent/demographic and/or interview data (Henson, 2002). The studies in this literature review followed that trend. Ten of the twelve utilized survey instruments and demographic questionnaires and relied on the self-reporting that accompanied them[1]. Five studies asked their participants to complete other accompanying instruments[2]; three of those were made by the researchers[3]; one was tested for reliability[4].

Five of the studies attempted validation of the efficacy instrument[5], but all five methods varied. The validation efforts ranged from use of a single, self-reported question regarding the participant's beliefs about their effectiveness as a science teacher (Enochs et al., 1995; Ramey-Gassert et al., 1996), multiple questions probing the levels and/or changes in teachers' beliefs about teaching science and what had caused those levels and/or initiated any change (Ginns & Watters, 1999; Haney et al., 2002). Bleicher (2006) validated his science teaching self-efficacy scores through the use of self-rated scores from journal reflections.

Five of the studies utilized interviews with open-ended prompts focusing usually on antecedents or classroom practices[6]; only two of these studies interviewed preservice teachers[7]. Three of the studies observed their participants as they taught in their beginning teacher classrooms[8]. No study observed the teaching of preservice teachers.

In terms of duration, seven of the twelve studies were less than three months in duration[9]. Seven only surveyed their participants once[10]. Without a pre- and post- or repeated longitudinal survey administrations, investigation of the development and factors that influence the development of efficacy beliefs is diminished. Gender was mentioned in nine studies and race once[11]. No study mentioned the participant's age or prior job experiences.

The above statements are based on the selection of studies for this review. However, the majority of them are also among the most frequently sited among the science teaching self-efficacy studies. Only two studies were almost identical replications: Raudenbush, Rowan, & Cheong (1992) and Ross, Cousins, Gadalla, & Hannay (1999). The majority of the studies seemed to administer the STEBI in a non-repetitive, one shot manner and investigated a variety of different educational topics.

Discussion and Conclusion

The mixed antecedent results suggest the need for further exploration into the influence of high school experiences and college science courses. The studies in this literature review point to the power of antecedents: positive antecedents are related to developing and maintaining higher levels of science teaching self-efficacy; negative antecedents are related to fueling the teacher's desire to not have their students endure negative experiences they themselves had as a student. The studies also point to the possibility of negative antecedent influences on science teaching self-efficacy beliefs. There is a need for researchers and teacher education programs to investigate these antecedent influences and to provide teachers with opportunities and experiences that aid in the development of higher science teaching self-efficacy.

The predominance of short term duration studies is a problem when it comes to investigating how science teaching self-efficacy beliefs develop and are influenced along a teacher's career path. A few of the newer studies framed their analyses on Bandura's four sources of efficacy: 1) mastery experiences – an individual's past successes and failures; 2) vicarious experience – skill in question is modeled by someone considered competent by and comparable to the individual; 3) verbal/social persuasion - encouragement received from a knowledgeable source and 4) physiological and affective states in their analyses. The efficacy source identification guide by Brand and Wilkins (2007) may provide a more valid way for researchers to investigate the efficacy sources that may be provided by their methods class or professional development workshop. The use of multiple researchers to code to these sources would add to reliability of a study and also add to the body of research.

In the studies reviewed, the interviewers did not investigate the participants' thinking and reasoning concerning the mark on the survey items. In the analysis phases of these studies, the researchers made the connections of the life/educational experiences to the survey answers. This was done in two of the studies presented here (Brand & Wilkins, 2007; Mulholland & Wallace, 2001). Only one study pointed out that their analysis: "imposed order and meaningfulness… our sense making evolved and emerged through our reading, thinking and discussion… the themes we use in the conclusions are our attempts to make sense of the connection between (the participant) and the theoretical notion of self-efficacy" (Mulholland & Wallace, 2001, p. 247).

With longer studies using methodologies involving the sources of efficacy and focused on reasons for survey answers, findings may better guide creation of teacher education programs, job contexts and professional development opportunities that enhance a teacher's science teaching self-efficacy beliefs. Armed with how to help teachers develop their teaching efficacy beliefs, teacher educators may be able to slow down the loss of science teachers to business and industry. If a greater number of efficacious science teachers remain in their classrooms and persevere with being good science teachers, students might likely enjoy and learn science more easily and their achievement scores might reflect that science knowledge.

However, the above statements are hypothetical. The design and methodological concerns presented in this literature review are shared by others in teacher efficacy research (Henson, 2002; Tschannen-Moran et al., 1998). The idea of teaching self-efficacy is a maturing construct, both in terms of its meaning and measure. Teacher efficacy research, grounded largely within social cognitive theory (Bandura, 1986), has been set within the conceptual and methodological approaches of psychology. Such a focus has resulted in research dominated by quantitative methodologies exploring relations among antecedents and consequences of science teaching efficacy beliefs.

Although such research has been successful in establishing the power of teaching efficacy beliefs there should also be recognition of the limits of such research and a consideration of other perspectives and methodologies (Labone, 2004).

In focusing on how efficacy information is sourced and processed by the participants, perhaps Henson’s aspiration is possible:

> "To fully understand the relationships the sources of efficacy information, the meaning teachers attach to this information, and any ultimate change in their efficacy beliefs, in-depth study of teachers is necessary" (Henson, 2002, p. 147).

Notes

[1] (Bleicher, 2006; Cantrell et al., 2003; Enochs et al., 1995; Ginns & Watters, 1999; Haney et al., 2002; Ramey-Gassert et al., 1996; Raudenbush, Rowan, & Cheong, 1992; Ross et al., 1999; Schoon & Boone, 1998; Tosun, 2000)

[2] (Bleicher, 2006; Enochs et al., 1995; Haney et al., 2002; Ramey-Gassert et al., 1996; Schoon & Boone, 1998)

[3] (Bleicher, 2006; Schoon & Boone, 1998)

[4] (Bleicher, 2006)

[5] (Bleicher, 2006; Enochs et al., 1995; Ginns & Watters, 1999; Haney et al., 2002; Ramey-Gassert et al., 1996)

[6] (Ginns & Watters, 1999; Haney et al., 2002; Mulholland & Wallace, 2001; Ramey-Gassert et al., 1996; Tosun, 2000)

[7] (Ginns & Watters, 1999; Tosun, 2000)

[8] (Ginns & Watters, 1999; Haney et al., 2002; Mulholland & Wallace, 2001)

[9] (Bleicher, 2006; Brand & Wilkins, 2007; Enochs et al., 1995; Raudenbush et al., 1992; Ross et al., 1999; Schoon & Boone, 1998; Tosun, 2000)

[10] (Enochs et al., 1995; Haney et al., 2002; Ramey-Gassert et al., 1996; Raudenbush et al., 1992; Ross et al., 1999; Schoon & Boone, 1998)

[11] (Cantrell et al., 2003; Enochs et al., 1995; Ginns & Watters, 1999; Haney et al., 2002; Mulholland & Wallace, 2001; Ramey-Gassert et al., 1996; Raudenbush et al., 1992; Ross et al., 1999; Tosun, 2000)

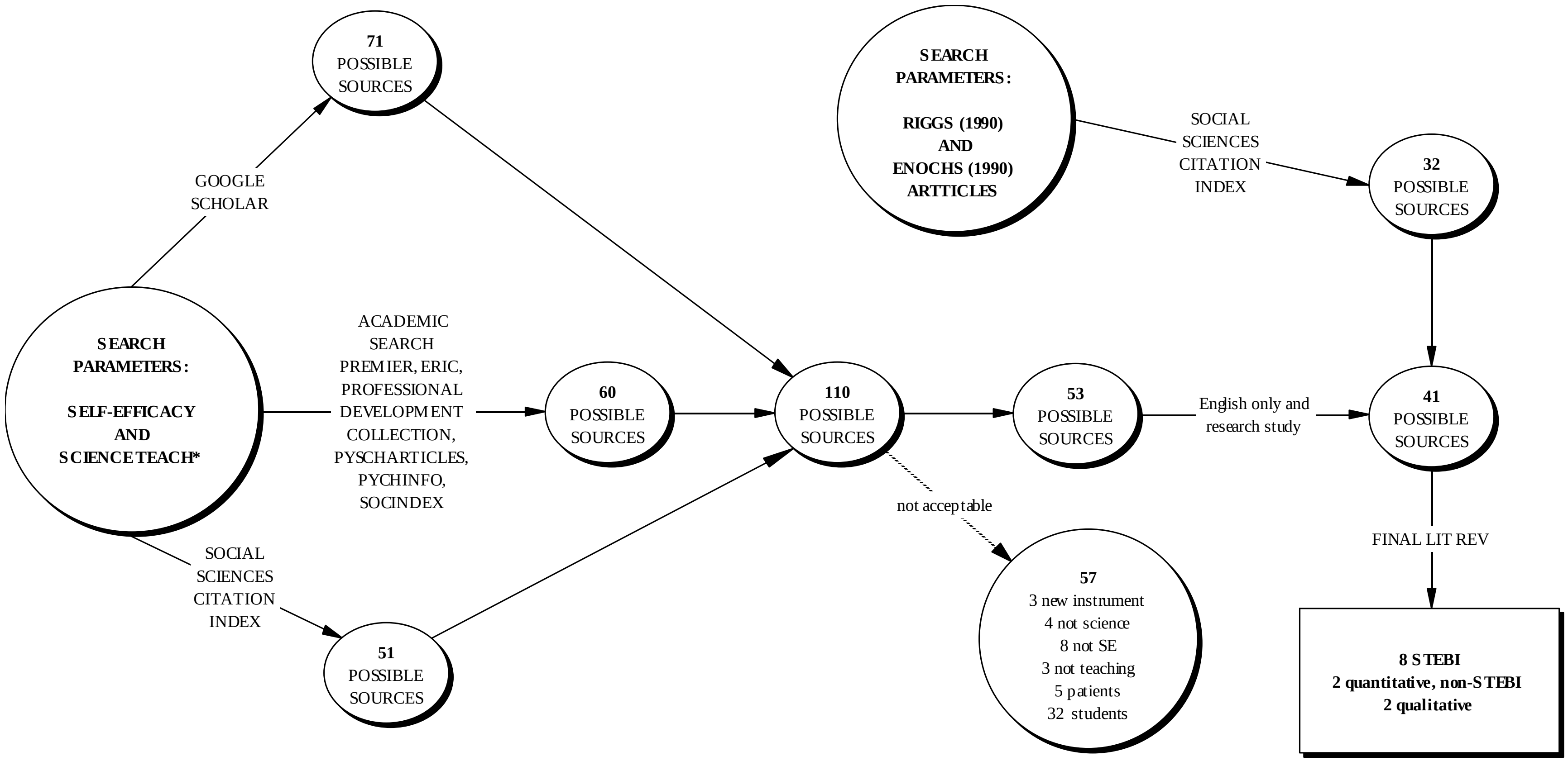

Figure 1. Selection of Studies for Literature Review

Table 1. Summary of Reviewed Studies

APPENDIX

Summary of reviewed studies

Publication	Purpose	Participants	Selection Aspect(s)	Collection Period	Data Sources
Bleicher, R., E. (2006)	investigated teaching efficacy and science conceptual understanding	70 preservice teachers enrolled in a science methods course	STEBI used; development of science content knowledge focus	pre field experience	(2) STEBI B administrations; reflection journals; science conceptual understanding test; field notes; instructor's journal
Brand, B. R., & Wilkins, J. L. M. (2007)	evaluation of methods course based on self-efficacy sources	50 master's degree preservice teachers enrolled in a science and math methods course	no instrument used; guide was developed to identify sources of self-efficacy; interrater reliability agreement performed	pre student teaching	participants'' beginning and course end written reflections
Cantrell, P., Young, S., & Moore, A. (2003)	investigated influences of antecedent life and teacher preparation program experiences on teacher efficacy	12 preservice elementary science teachers	STEBI used; investigated one cohort over their entire preservice year	entire year of teacher preparation program	(3) STEBI B administrations; demographic questionnaire

Publication	Purpose	Participants	Selection Aspect(s)	Collection Period	Data Sources
Enochs, L. G., Scharmann, L. C., & Riggs, I. M. (1995)	investigated teacher efficacy, characteristics and pupil control	73 elementary preservice teachers enrolled in science methods class	STEBI used; explored areas of antecedent science classes (HS and college)	pre field experience	(1) STEBI B/pupil control administration; demographic questionnaire
Ginns, I. S., & Watters, J. J. (1999)	investigated teacher efficacy and classroom practices	3 elementary preservice teachers	STEBI used; longitudinal in nature; science teaching behavior focus	entire year of teacher preparation program and into 2nd year as novice teacher	(4) STEBI administrations; (2) semi structured interview focused on developing practices; discussion w/school administration; classroom observation
Haney, J. J., Lumpe, A. T., Czerniak, C. M., & Egan, V. (2002)	investigated teaching self-efficacy and context beliefs and teacher's ability to effectively implement science instruction	6 inservice elementary teachers involved in NSF grant PD	STEBI used; utilized an instrument to investigate context influences	surveys given prior to summer workshop; observations done spring of following year	(1) STEBI/CBATS/ demographic questionnaire administration; (1) observation; open ended interview focused on teaching abilities and prior/current job context

Publication	Purpose	Participants	Selection Aspect(s)	Collection Period	Data Sources
Mulholland, J., & Wallace, J. (2001)	investigated participant's teaching practices and sources of self-efficacy	1 elementary science preservice teacher through 1st yr novice	no instrument used; longitudinal in nature; science teaching behavior focus	majority of teacher preparation program and into 1st year as novice teacher	reflective journal; interviews; classroom observations
Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996)	investigated influences of antecedent life and professional development experiences on teacher efficacy	23 elementary inservice teachers	STEBI used; explored many personal antecedent areas; investigated the importance of the job context	3 year period during professional development program	(1) STEBI/science attitude/demographic/ antecedent survey administration; exploratory interview focused on experiences
Raudenbush, S. W., Rowan, B., & Cheong, Y. F. (1992)	investigated teaching efficacy and class characteristics	315 inservice high school teachers	usage of non-STEBI instrument; HLM modeling and analysis of high school subjects and class levels	single administration during school year	(1) non-STEBI instrument/demographic/professional questionnaire administration

Publication	Purpose	Participants	Selection Aspect(s)	Collection Period	Data Sources
Ross, J. A., Cousins, J. B., Gadalla, T., & Hannay, L. (1999)	investigated teaching efficacy and teacher course assignment	359 inservice high school teachers	usage of non-STEBI instrument; MLR analysis of high school course characteristics to teaching specialization	single administration during June of school year	(1) non-STEBI instrument/demographic/professional questionnaire administration
Schoon, K. J., & Boone, W. J. (1998)	investigated teaching efficacy and alternative science conceptions	619 elementary preservice teachers enrolled in science methods classes	STEBI used; development of science concept knowledge and possible, "critical barriers"	pre student teaching	(1) STEBI/alternative science conception test administration
Tosun (2000)	investigated prior science achievement	44 elementary preservice teachers enrolled in science methods classes	STEBI used; explored areas of antecedent science classes (HS and college)	prior to first methods class	Science achievement/experience history questionnaire; STEBI B used for interview prompts

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TOWARD MAKING THE INVISIBLE VISIBLE:
A VALIDATION STUDY OF THE STEBI

Catherine J. Perkins
Larry G. Enochs
Emily van Zee

Journal of Science Teacher Education
233 Springer Street
New York, NY 10013
To be submitted

Science and Mathematics Education
Oregon State University, 239 Weniger Hall, Corvallis, Oregon 97331-6508
T 541-737-1305 | **F** 541-737-1817 | www.oregonstate.edu/dept/sci_mth_education

September 17, 2007

Charlene M. Czerniak, Editor-in-Chief
University of Toledo, Ohio

Dear Dr. Czerniak:

Enclosed is an unsolicited manuscript submitted for possible publication in the *Journal of Science Teacher Education* entitled "Toward Making the Invisible Visible: A Validation Study of the STEBI."

Our intent during the development of this manuscript was to extend the science teaching self-efficacy research base. This study utilized multiple STEBI administrations during the preservice and beginning year of teaching for two science teachers. Rather than general questions, these participants were asked item specific, yet open-ended, questions to determine what events or experiences the participants felt influenced their survey answers. This methodological approach was chosen to add clarity to the STEBI scores and to add another layer in the ongoing process of instrument validation. Unlike some studies in science teaching self-efficacy, both participants' STEBI scores continued to increase as they transitioned from preservice to beginning teachers. The participant responses to the focused interview probes also validated their STEBI scores 77% of the time.

Any consideration you may give concerning this manuscript will be appreciated.

Sincerely,

Catherine J. Perkins

Please address all correspondence as follows:
Catherine J. Perkins
Science and Mathematics Education Department
239 Weniger Hall
Oregon State University
Corvallis, OR 97331
Email: cperkins@archdpdx.org
Cc Larry G Enochs

Chapter 3: Toward Making the Invisible Visible: A Validation Study of the STEBI

Introduction

United States policy makers and the public alike have voiced concerns regarding teacher quality, preparation and retention. In the area of science education, these concerns are fueled by three facts: 1) the relatively low achievement scores of United States students (National Assessment of Educational Progress, 1990, 2006; National Commission on Excellence in Education, 1983; Third International Mathematics and Science Study, 1996), 2) the relationship of American global competitiveness to the science education and development of a non-agrarian/industrial workforce (Schmidt, 1997; Wise & Leibbrand, 2000), and 3) the loss of almost half of the beginning teachers within the first five years of teaching, with science and mathematics teachers the most likely to leave in comparison to other teachers (Guarino, 2006; Henke, 2001; Liu, 2007).

In response to these achievement scores and the changing workforce concerns, many groups created reform policies regarding classroom curricula and practice (American Association for the Advancement of Science, 1989, 1993; American Psychological Association, 1997; National Research Council, 1996). Teacher preparation programs started to shift their focus. Traditional teacher preparation programs had been positivist in nature where the university provided the theory, skills and knowledge, the school provided the field setting where knowledge is applied and practiced and the preservice teacher provided the effort that integrated it all. A typical program of this time treated learning to teach as an additive process that bypassed potential influences within the person and at the field setting (Feiman-Nemser & Buchmann, 1987). Based on the work of Pajares (1992) and Richardson (1996), the importance of beliefs held by individuals prior to their entering a preservice program began to be incorporated as a more productive approach in learning how to teach. Teacher preparation programs that were aligned with the field experience were shown to have a positive impact on preservice teachers' development. This alignment provided support for learning and practice that included theory and multiple opportunities to attempt the desired practice and to ask questions about those attempts. This trend was seen across grade levels and contexts and emphasizes planned, guided and sustained interactions with children and adolescents (Cochran-Smith & Zeichner, 2005).

Today, although many teacher education programs utilize the reform documents in aligned and congruent field experiences - practicing one's beliefs is neither linear nor simple. The reform documents for science instruction have been in the educational field for two decades and evidence of their impact is weak on a national (Hiebert & Stigler, 2000; Pasley, Weiss, Shimkus, & Smith, 2004) and local scale (Judson & Sawada, 2001a; Schepige et al., 2004). Practices advocated by the reform documents are difficult to learn and, even when they are learned, may not necessarily be utilized in the first years of classroom teaching (Grossman, Valencia, Evans, Thompson, & Martin, 2000; Grossman, Valencia, Evans, Thompson, Martin et al., 2000). The likelihood of seeing reform based science instruction is even less likely given the attrition trends for science teachers (Henke, 2001). Although policymakers and the public hope for solutions, one teacher characteristic that has been consistently related to student achievement ((e.g., Armor et al., 1976), $r = 0.37$. $p < 0.05$) implementation of innovation ((e.g., Ghaith & Yaghi, 1997), $r = 0.62$. $p < 0.05$) and commitment teaching ((e.g., Ware & Kitsantas, 2007), $r = 0.37$. $p < 0.01$) is a teacher's teaching efficacy beliefs.

Teaching self-efficacy is defined as teachers' beliefs in their "ability to bring about change in their students" (Soodak & Podell, 1997, p. 215). Although studies showed consistent results with inservice teachers, the findings are mixed concerning the development of teaching efficacy beliefs in preservice teachers., Differing preservice teacher results have been reached in studies utilizing a generalized teaching self-efficacy instrument (Gibson & Dembo, 1984). Soodak and Podell (1997), for example, saw a decrease and Woolfolk Hoy and Spero (2005) saw an increase in teaching self-efficacy beliefs at different preservice program stages. Science teaching self-efficacy beliefs have also received similarly mixed finding: increases in preservice teachers' science teaching self-efficacy were seen (e.g., Cantrell et al., 2003) as well as decreases (e.g., Ginns & Watters, 1999).

The majority of educational research dealing with self-efficacy beliefs relies on the administration of a survey instrument and the collection of antecedent/demographic and/or interview data (Henson, 2002). Interviews have not usually investigated the participants' thinking and reasoning concerning the ways they marked the scales on the survey items. In the analysis phases of these studies, the researchers make the connections of the life/educational experiences to the survey answers. Survey scores are a function not only of the items, but also of the persons responding (Messick, 1995). This study therefore utilized interviews which not only queried the participants about their antecedent/demographic backgrounds but also queried them about their thinking concerning those survey scores.

Theoretical Framework and Literature Review

Self-Efficacy Beliefs

Beliefs are part of the foundation upon which behaviors are based. This review considers beliefs from a philosophical perspective: beliefs are propositions that do not require a truth condition and that are accepted as true by the individual holding the belief (Green, 1971). This study examined beliefs through a lens based in social cognitive learning theory (Bandura, 1986, 1997). Human agency is defined as the power to intentionally originate actions for a given purpose - the power to make things happen. Individuals act on this intention if they are confident that they can perform that action successfully (Bandura, 1977). The performance is dependent on not only the individual's beliefs but also on the environment and the behavior itself. Bandura called this a transactional social cognitive view of self and society in which the self is socially constituted and individuals are partial contributors to what they become and do. Bandura set human agency within the triadic causal response model, see Figure 1.

The interdependent structure below is composed of three determinants: 1) personal factors: internal factors in the form of cognitive, affective, and biological events (personality characteristics, cognitive processes and beliefs), 2) behavior (the nature, frequency, and intensity of the action) and 3) environmental: external factors (stimuli from social or physical environment). These three sets of determinants are not of equal strength, do not occur simultaneously and take time to exert their influence on the individual and their actions (Bandura, 1997).

Located in the personal factors determinant of Bandura's above structure, self-efficacy is defined as the belief in one's capabilities to organize and execute the courses of action required to produce given attainments (Bandura, 1977). Teachers' self-efficacy is their belief in their ability to bring about change in their students by successfully accomplishing a specific teaching task in a particular context (Soodak & Podell, 1997; Tschannen-Moran et al., 1998). These self-efficacy beliefs are future-oriented judgments about capabilities to organize and execute the courses of action required to produce given attainments in specific situations or contexts' (Bandura, 1997). For Bandura, a teacher's behavior is based on two factors: self-efficacy (teacher's beliefs about their own ability to execute specific actions) and outcome expectancies (teacher's beliefs about the effects that specific teaching actions have on students).

Bandura (1977) identified four sources that inform the individual's sense of self-efficacy: 1) mastery experiences – an individual's past successes and failures; 2) vicarious experience – skill in question is modeled by someone considered competent by and comparable to the individual; 3) verbal/social persuasion - encouragement received from a knowledgeable source and 4) physiological and affective states – somatic information conveyed by physiological and emotional arousal.

According to Bandura's theory, teaching self-efficacy is a domain specific construct which focuses on the teachers' perceptions of their ability to: "organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran et al., 1998, p. 233). Efficacy judgments are beliefs about one's own capabilities not necessarily accurate assessments of those capabilities. One aspect that makes teaching self-efficacy so powerful is its cyclical nature (Tschannen-Moran et al., 1998):

> the proficiency of a performance creates a new… experience, which provides new information that will be processed to shape future efficacy beliefs. Greater efficacy leads to greater effort and persistence, which leads to better performance, which in turn leads to greater efficacy. The reverse is also true. Lower efficacy leads to less effort and giving up easily, which leads to poor teaching outcomes, which then produce decreased efficacy. (p. 233)

A completed teaching performance that was accomplished with a level of effort and persistence influenced by the teacher's sense of efficacy becomes the past and a source of future efficacy beliefs. Preservice teachers, because of their newness to the teaching profession, may have limited experiences. Bandura (1977) postulated and research has confirmed that efficacy is most malleable in the preservice years (Housego, 1992; Hoy & Woolfolk, 1990). Research has also confirmed that once efficacy beliefs are established they are resistant to change (Henson, 2002).

Science Teaching Self-Efficacy Beliefs: Measurement and Trends

Based on a search of the preservice science teaching self-efficacy literature, strictly qualitative studies are rare (Mulholland & Wallace, 2001). The majority of studies are quantitative in nature and utilize surveys (Henson, 2002; Tschannen-Moran et al., 1998). The first instrument to measure teacher efficacy originated in the RAND study that evaluated 100 Title III projects associated with the 1965 Elementary and Secondary Education Act (Berman et al., 1977). These researchers used two efficacy items and investigated teachers' beliefs concerning aspects the teachers felt they could control (or at least strongly influence) in their school and their students' achievement and motivation. The results pointed to teaching self-efficacy beliefs as the most important factor when it came to teachers' promoting their students' learning and motivation. These results were confirmed in studies on implementation of new school or district programs (Ashton & Webb, 1986; McLaughlin & Marsh, 1978), Gibson and Dembo (1984) extended the research and found that self-efficacy was comprised of two separate and uncorrelated factors: factors they called personal teaching efficacy and teaching outcome expectancy. However, efficacy is a situation and context specific construct (Bandura, 1981). Teachers may feel quite efficacious concerning some classes and feel quite the opposite in other content areas. A general efficacy instrument, like Gibson and Dembo's, proved to be ineffectual at capturing these content specific situations. Modifications of the Gibson & Dembo instrument were therefore made within particular content areas.

The Science Teaching Efficacy Belief Instrument (STEBI A) was initially created by Riggs & Enochs (1990). Through a quantitative study with preservice elementary teachers, these researchers, confirmed that the personal science teaching efficacy and teaching outcome expectancy constructs were distinct, valid and reliable The STEBI A scores represented elementary teachers actual beliefs about their ability to teach science: “Item 2: I am continually finding better ways to teach science” (Riggs & Enochs, p. 636). Enochs & Riggs continued to add to the efficacy research base and developed a similar instrument (the STEBI B) to measure the science teaching self-efficacy beliefs of preservice teachers based on their anticipated beliefs about their ability to teach science: “Item 2: I will continually find better ways to teach science” (Enochs & Riggs, 1990, p. 711). Widely used in subsequent years, the STEBI has been adapted into a chemistry form (Rubeck & Enochs, 1991) and a mathematics form (Enochs et al., 2000). The STEBI surveys used in this study can be found in the Appendices.

Antecedent Experiences

Experiencing science as a student seems to be influential on science teaching self-efficacy levels and on choosing to become a science teacher. When discussing K-12 experiences, participants often attributed high science teaching self-efficacy scores to positive experiences (Ramey-Gassert et al., 1996). Teachers who had a high confidence in their ability to teach science often, however, also had negative early science experiences as children (Mulholland & Wallace, 2001). According to the research, these individuals vowed that their students would never have those types of experience and persevered in creating positive learning experiences for their students.

High school science was also influential on science teaching self-efficacy beliefs, but with mixed results. Cantrell, Young, & Moore (2003) found significantly positive correlations between the number of science classes taken, the number of years of high school science and participation in extracurricular science activities and higher science teaching self-efficacy beliefs. The Enochs, Scharmann & Riggs (1995) study found, however, that the years of high school science were significantly and negatively related to science teaching self-efficacy beliefs. The discrepancy in high school results may be the result of sample differences due to the location and time difference between the two studies. High schools that Cantrell's participants attended may have been in a state that actively incorporated reform based science teaching practices – some of which were reflected in some of the STEBI items.

As they enter college, elementary preservice teachers science content knowledge was reported to be low or in need of development (Bleicher, 2006; Schoon & Boone, 1998). Two studies (Enochs et al., 1995; Ramey-Gassert et al., 1996), both using samples from the same geographical location, found significant negative correlations between the number of science courses taken and the preservice student's choice to teach science.

Teacher Education Programs

Although the majority of the studies ended on a positive note (i.e. self-efficacy levels improved or rebounded), the path was not linear and in some of the longitudinal studies it was even cyclical (Mulholland & Wallace, 2001). This was particularly evident after student teaching, where preservice teachers usually experienced a decrease in efficacy, perhaps due to over-inflated personal or underestimated context complexity beliefs (Ginns & Watters, 1999). Without exception, teacher education programs that incorporate many and early field experiences were generally and significantly related to increases in science teaching self-efficacy (Cantrell et al., 2003). Researchers advocated gradual field experiences would aid in the development of the preservice teacher's efficacy beliefs. Preservice teachers' science content knowledge and teaching self-efficacy levels improved when they were provided activity-based opportunities to interact with science content in science methods classes (Bleicher, 2006; Brand & Wilkins, 2007).

Jobsite Context

Another theme in the science teaching self-efficacy beliefs research was the potentially positive influence a supportive context during preservice field experiences and jobsite might have (Haney et al., 2002). The support did not necessarily have to be from co – science teachers to have a positive and significant impact on inservice science teachers' self-efficacy beliefs (Ginns & Watters, 1999). Higher science teaching self-efficacy belief levels were attributed to student support and the positive reactions from students were also attributed to higher science teaching self-efficacy levels (Ginns & Watters, 1999; Mulholland & Wallace, 2001) as were the positive and significant influence from administrative support (Haney et al., 2002; Ramey-Gassert et al., 1996).

Only two studies (Raudenbush et al., 1992; Ross et al., 1999) were found that investigated science teaching self-efficacy beliefs at the high school level and both were included in this literature review. Both found science teachers' self-efficacy beliefs to be directly connected with the level of preparation they felt going into the science classroom. These researchers also both published significant correlations between high school science teacher's science teaching self efficacy and the level or track of science class they taught.

Design and Methodological Issues

The majority of educational research examining science teaching self-efficacy beliefs relies on the administration of an instrument and the collection of antecedent/demographic and/or interview data (Henson, 2002). Short term, single survey administration methodologies predominate in correlational studies. Longitudinal studies across teacher preparation programs and the first several years in the field could begin to map the development of teaching self-efficacy beliefs and could assess the impact of different teacher preparation programs and practices (Tschannen-Moran et al., 1998).

Others have noted that teachers' self-efficacy beliefs cannot be studied adequately using only surveys (Wheatley, 2005). Although teacher self-efficacy beliefs are unlikely to be probed effectively using . . . Likert-scaled instruments (Hebert, Lee, & Williamson, 1998), the interviews used in conjunction with the surveys often focus on the connections of the life/educational experiences to the survey answers (Ginns & Watters, 1999). The researchers: “impose order and meaningfulness and their findings are often attempts to make sense of the connection between (the participant) and the theoretical notion of self-efficacy” (Mulholland & Wallace, 2001, p. 247). Although such research has been successful in establishing the power of science teaching self-efficacy beliefs there should also be recognition of the limits of such research and a consideration of other perspectives and methodologies (Labone, 2004). In focusing on how efficacy information is sourced and processed by the participants, perhaps Henson’s aspiration is possible:

> "To fully understand the relationships the sources of efficacy information, the meaning teachers attach to this information, and any ultimate change in their efficacy beliefs, in-depth study of teachers is necessary" (Henson, 2002, p. 147).

Therefore, the purposes of this study include seeking a greater understanding of the factors that facilitate or inhibit the development of teaching efficacy beliefs among science teachers across stages of their careers. The second purpose focuses on the documenting of the meaning that a mark on a scale had for these participants. In this study, the participants were making the connection between their responses to a STEBI item and their beliefs and experiences - not the researcher. Through analyzing those connections, this study also explores the validity of the participants’ survey scores in relation to their responses. Research questions include:

(a) What science teaching self-efficacy beliefs do preservice science teachers have at various points of time during their teaching preparation program?
(b) How do science teaching self-efficacy beliefs change during their subsequent, beginning year of teaching?
(c) What meaning do participants give to the mark they make on the Likert scale in responding to items about science teaching self-efficacy?
(d) To what are changes in personal science teaching self-efficacy attributed?

(e) To what degree are the science teaching self-efficacy beliefs instrument's scores valid based on participants' statements?

Study Limitations

This study had two sources of limitations: those created through conscious decisions made by the researcher and those created by the study's participant sample. Two individuals, from a population of 23 preservice teachers, comprised this sample. They were not randomly chosen, but purposively chosen by the researcher for their extreme science teaching self-efficacy beliefs scores. This study's findings may or may not be influenced by this extreme study aspect and consequently it is recognized that any findings are only generalizable to the participants themselves. Teacher efficacy beliefs are important influences on motivation and behavior in part because they mediate the relationship between knowledge and action (Pajares, 1996). Although agreeing with the former sentence, due time and limited access to classrooms, this study does not investigate participants' actions or classroom practices.

Another decision made by the researcher was to limit the study to science teaching self-efficacy beliefs. For Bandura (1977), a teacher's behavior is based on two factors: self-efficacy beliefs (teacher's beliefs about their own ability to execute specific actions) and outcome expectancies (teacher's beliefs about the effects that specific teaching actions have on students). The focus of this study was on science teacher's beliefs about their abilities to teach science. It is acknowledged that outcome expectancies may indeed be influential in regards to human behavior. However, with outcome expectancies' lower reliability coefficient noted in earlier studies (Enochs & Riggs, 1990; Huinker & Madison, 1997; Plourde, 2002) it has been suggested that outcome expectancy is a less definite construct, and thus more difficult to measure accurately (Riggs & Enochs, 1990). For these reasons, this study's focus remained science teaching self-efficacy beliefs.

This study's participant sample included 2 female, secondary science teachers. Although self-efficacy beliefs have been reported to be significantly related to gender (Cantrell et al., 2003; Raudenbush et al., 1992) this study's sample did not allow exploration of this relationship. Nor did this sample allow for the investigation of individuals possessing low science teaching self-efficacy beliefs. Both participants had med and high levels of science teaching self-efficacy beliefs and ended the study in the high category. The extent to which this study's findings are applicable to individuals of lower science teaching self-efficacy beliefs can not be determined by this study.

Content background has been found to be significantly related to teaching self-efficacy beliefs (Desouza, Boone, & Yilmaz, 2004; Ramey-Gassert et al., 1996). As a requirement of the teacher preparation program, both participants held science baccalaureate degrees and had taken numerous courses in their respective teaching concentration (physics and biology). Limited to participants in this particular teacher preparation program, individuals without a science related degree or possessing lesser amounts of science coursework was not possible.

Methods

This study was based on the case studies of two secondary, science teachers. It was longitudinal in nature and collects data from their preservice and first year of teaching. Survey data helped with the investigation of the levels and changes of their science teaching self-efficacy beliefs. Interview data helped with the determination of possible sources for those science teaching self-efficacy beliefs. Comparing their interview statements to their scores helped to investigate the validity of the science teaching self-efficacy survey.

Participants

This study examined the perceptions of two Caucasian female secondary science teachers about their responses on a widely used survey instrument, the Science Teaching Efficacy Belief Instrument (i.e. STEBI (Enochs & Riggs, 1990; Riggs & Enochs, 1990)) over a span of two years. Both participants were enrolled in a one-year graduate teacher preparation program that resulted in a Master of Science degree in science education and qualified the participants for state teacher licensure for grades 3-12 in the area of science. Their cohort included 23 participants (5 males, 18 females) with an undergraduate degree in a science related field. Three were seeking primary certification in chemistry, four in Physics, and 16 in Biology. These individuals were selected from their cohort on the basis of their having complete survey data sets, their survey scores (determined by STEBI z scores (see Appendices), and their availability and willingness to participate in this study. Both participants were older than the average age of their cohort (mean = 29.65 years) and at the end of this study were working as first year teachers at the sites where they did their student teaching.

Data Collection and Analysis

To investigate science teaching efficacy beliefs and their attributes, this study utilized both quantitative and qualitative methods. The quantitative data originated from six administrations of the STEBI and an antecedent survey (Cantrell et al., 2003). Figure 3 shows the survey administration timeline in relation to the teacher education experiences.

August – September 2005			October – December 2005		January – March 2006		April – June 2006		September - June 2007	
STEBI I administered Sept 23	Summer Intensive Course September Experience: Weekly seminar while fulltime in the classroom	**STEBI II** administered Sept 23	**STEBI III** administered Oct 3	Part time Course Work Part time Student Teaching Practicum	Preparation of Worksample	**STEBI IV** administered Mar 23	Fulltime Student Teaching	**STEBI V** administered June 16	1st year Beginning Teaching	**STEBI BT & Antecedent survey** administered May 15

Figure 1. Survey administration and Teacher Education Program Timeline

The Science Teaching Efficacy Belief Instrument (STEBI) was initially created by Riggs & Enochs (1990) and had its origins from two sources: Bandura's social cognitive theory (Bandura, 1977) and Gibson & Dembo's Teacher Efficacy Scale instrument (Gibson & Dembo, 1984). A shortened form of the subject specific STEBI was used for this study (see Appendices). The STEBI is a Likert item questionnaire with each self-efficacy item having five response ratings: strongly agree (5 points), agree (4 points), uncertain (3 points), disagree (2 points), and strongly disagree (1 point). See example below:

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

Items that were intended to produce a negative response have an "R" by their item number and their scoring is reversed (i.e. 1=5; 2=4) for scoring purposes. The numeric scores of the STEBI facilitated the determination of the levels of and possible changes in science teaching self-efficacy beliefs during the participants' preservice program and at their first jobsites. The STEBI surveys used in this study can be found in the Appendices.

Cantrell, Young, & Moore's questionnaire (2003) was designed to investigate antecedent demographic information. Antecedent factors such as science activities in and out of school and science teaching experiences have been found to be related to science teaching efficacy (Ramey-Gassert et al., 1996). See example below:

Antecedent Survey Item 9	Please list any job or professional experience you have had that involved the usage of mathematics or science.

Both surveys (see Appendices) provided information that was used to help create a profile for each teacher and to trace the participants' science teaching efficacy beliefs at various points of time during their teaching preparation program and first year of teaching.

The qualitative data originated from two interviews and emails. The first interview focused on the participant's antecedent information and general discussion about the preservice program, teaching, and the first teaching year. This first interview was conducted to help increase the researcher's knowledge regarding the participant's mindset, background, and school contexts. The subsequent interview and emails utilized open-ended questions focused solely on the participant's STEBI responses and to what the participant attributed the levels and changes in the survey scores. An example interview question is provided below. Details about interview questions and discussion can be found in the Appendices.

(interview lines 1211-1219)
Researcher: Looking at the dip, we are talking about, finding those better ways, bigger and better, why was it a little bit lower in the first practicum before you hit student teaching? Any ideas?

For each of the participants, the interview data were transcribed and coded to the 13 self-efficacy items found in the STEBI (see Appendices). Each worksheet of the database contained the participant's STEBI scores for a STEBI item and interview data specifically related to this item. Such excerpts from the interviews included the participant's attributions as to her score levels or changes in the scores and also comments that the researcher felt provided insight or antecedent information related to those attributions. An assessment of interrater agreement was performed on the 13 worksheets for substantiating trustworthiness (Miles & Huberman, 1994). Collapsed over all the items for both participants, there was a 95% agreement in regards to the placing of the participants' interview statements into the appropriate STEBI item worksheet (see Appendices). These percentages provide evidence of the consistency with which the interview statements were coded to the appropriate survey item.

After coding to the survey items, the interview data were then clustered along themes found in the STEBI (Miles & Huberman, 1994). The four clustering categories were submitted for review to two professionals active in science teaching efficacy research and found to be reasonable and valid: 1) classroom teaching practices, 2) interactions with students, 3) science content knowledge and 4) science experiments (see Appendices). For each of the four categories, a case orientated analysis was conducted on the items that made up the category and configurations and associations were sought within each participant's case (Borman, Clarke, Cotner, & Lee, 2006).

The coding to the 13 STEBI items and to the four clustering categories represented the first level of the coding process (Miles & Huberman, 1994). The within case analyses organized the STEBI survey scores and interview sections in a time ordered meta matrix based on the STEBI administrations (an example is provided in Table 40 of the Appendices). For each STEBI item, a participant was asked to elaborate on the origin of their STEBI scores for three distinct time periods: 1) at the very beginning of their teacher education program (survey administration I), 2) during their teacher preparation program (survey administrations II -V) and 3) at the end of their beginning year (survey administration BT). Using the findings from each of the items comprising the category, a category synthesis was created for each participant. Patterns and themes for each participant were noted regarding her survey scores and their attributes. A cross-case analysis was done by comparing the participants' category syntheses to see whether there were patterns that transcend the particular cases for each category.

Prompted by the statement that the construct validity of an instrument is never fully established or achieved (Nunnally, 1970), this study also sought to add to the validity research of the STEBI instrument. To determine the validity of the STEBI instrument, the responses from the three distinct time periods (see above paragraph) were studied to determine the degree of their alignment with the participant's STEBI scores for these time periods.

By investigating the science teaching efficacy beliefs of two preservice secondary science teachers during their teaching preparation program and first year of teaching, this study sought to determine to what these teachers attributed the levels and changes in their personal science teaching efficacy. The findings are limited to the context of these two individuals. A majority of efficacy research has been self-report, survey and correlational in nature (Henson, 2002). However, by exploring the processes and outcomes across two cases and ways they are qualified by local conditions, it is hoped that a more sophisticated description and powerful explanation might be offered (Miles & Huberman, 1994).

Findings

Profiles of the two participants are presented below. These were based on the participants' antecedent survey responses and interviews, email and letter statements. Each profile describes the participant's mindset, background, and school contexts. The results are organized by the four themed categories mentioned earlier: 1) classroom teaching practices, 2) interactions with students, 3) science content knowledge and 4) science experiments (see Appendices). For each of these categories, the participant's associated STEBI scores and interview, email and letter statements were analyzed for patterns. After these within-case results are presented, the cross-case results are presented to identify patterns that transcend the particular cases for each category.

Participant Profiles

Willa's Profile

Willa was a white, married, 45 year old participant with an elementary age son. She took the standard sequence of high school science classes (biology, chemistry and physics) and participated in extracurricular science activities: "I loved my physics class in high school and I liked science… I actually did quite a few things. I was, like, in the Maryland Junior Academy of Science and things like that" (interview lines 149-150). Besides completing her preservice MAT program, she had also completed the course work and received a baccalaureate and a master's degree in engineering. Prior to entering the MAT program, Willa had worked as a failure analysis engineer for an integrated circuit manufacturing company where her husband also worked. When asked why she entered the MAT program, Willa stated that she:

> (interview lines 226-227, 37-40).
> "never woke up any day and felt like I would be a science teacher. I felt like this type of a job would fit the things that I was looking for. I wanted a schedule that I could fit more of my son's time in, and also be more in

> the community. Teaching at a school fit that better. We are also not big spenders, so the money itself wasn't the biggest factor that I was looking for."

Willa chose to student teach and work at the same high school where she did her student teaching. Her decision was influenced by two factors: she lived in the same city as the high school and she wanted to give back to her community. As she completed the STEBI survey at the end of her beginning teacher year, Willa was a full time teacher of 4 conceptual physics and 1 honors physics class. She had accepted the high school's offered contract for the next year, and also had been accepted into summer professional development programs at MIT and Cornell.

Stephanie's profile

Stephanie was a 31 year old, single, white participant. She had grown up on a cattle ranch surrounded by animals and had: "always been interested in the science… since I was about seven" (interview line 606). Although she had taken the biology, chemistry and earth sciences series, she had not participated in extracurricular science during high school. She entered university as a pre-vet major. Time spent as a veterinary assistant caused Stephanie to shift her career focus into getting a degree in biology and working as a university teaching assistant. In working with adult students, Stephanie first thought she might want to become a science teacher: "this is kind of cool. I kind of like this" (interview line 737). When asked why she switched to teaching younger students, Stephanie replied:

> (interview lines 766-787)
> "I got a lot of exposure teaching to adults, and that is when I realized, you know, all of these adults have already figured out their path in life. They know what they want to do. That's great, but they don't really need a lot of help from me. I am like, well, I would kind of like to get them a little bit earlier and maybe help them find their path."

Stephanie completed her MAT preservice program and was invited by her mentor to job share and return to the high school where she had student taught:

> (Interview lines 108, 143, 149-152)
> “We (*Stephanie and her mentor*) had a really wonderful rapport and I loved the school and I really enjoyed my student teaching experience there. I know all the school policies already. I knew some of the students already. I know all my co-workers. I knew the principal. So it was a much more comfortable atmosphere than going in some place completely new and having to be a first year teacher, having to get to know everyone, having to get to know the school climate and the policies, and try to teach to the best of my ability. Going back and being a first year teacher at a school I was already familiar with was great.”

As she took the last STEBI survey at the end of her beginning teacher year, Stephanie was a half time teacher of 3 classes of 10th grade biology. Due to her one year job sharing contract, she did not have another teaching job to go to and was actively searching for one. To increase her knowledge regarding forest ecology and use it in teaching her future students, she had accepted a summer position in which she shadowed and worked with forestry employees.

Classroom Teaching Practices Category

This category is comprised of items focused on the teacher’s beliefs regarding her behavior in a general classroom setting. The STEBI self-efficacy items that are included in this category are:

Item 2 - I will continually find better ways to teach science.
Item 3R - Even if I try very hard, I will not teach science as well as I will most subjects.
Item 8R - I will generally teach science ineffectively.
Item 19R - I wonder if I will have the necessary skills to teach science.
Item 20R - Given a choice, I will not invite the principal to evaluate my science teaching.
Item 21R - 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.

Willa’s Within Case Analysis

Table 2. Item 2 Score for Willa

item #	I	II	III	IV	V	BT
2	I will continually find better ways to teach science.					
	4	**5**	**4**	**4**	**4**	**5**

In reviewing her scores for this item, Willa agreed that she would continue to find better ways to teach science: “If I marked 4 or 5, I felt pretty confident that I would do this” (email communication line E3). Willa proceeded to elaborate on what she had done during her beginning teaching year:

> (letter communication lines L16-19)
> “For my teaching, I used a CPS (*an electronic student response system using clickers*), added lots of questions and images for mini-lectures. I had some warm-ups or demos at the beginning of class. I also did at least one and, most of the time, more than one activity per week. I believe that I implemented and accomplished quite a lot for a first year teacher.”

Table 3. Item 3 & 8 Score for Willa

item #	I	II	III	IV	V	BT
3R	Even if I try very hard, I will not teach science as well as I will most subjects.					
	4	**4**	**4**	**4**	**4**	**5**
8R	I will generally teach science ineffectively.					
	4	**4**	**4**	**4**	**4**	**4**

Once saying she was: "pragmatic" (interview line 239), Willa stated she would not have joined the MAT program if she had thought she would teach ineffectively. At the beginning of her preservice program, she was confident in her science knowledge, especially in her field (engineering) and in her belief that she could assist students in their learning: “I always believed that I could assist students in learning, otherwise I would not have gone into teaching” (email communication line E100). She was not as certain in her teaching knowledge and skills. She attributed the preservice program with providing her some key and useful information, especially in ways to communicate her science knowledge:

> (email communication line E15-22)
> “When I first began classes, I was not certain if I knew how to teach (I did not, that is why I was in class). The courses provided me with a way to learn how to communicate what I know and what others know to the students…”

Consistently stating that beginnings were somewhat hard because of her lack of teaching knowledge, Willa just as consistently expressed her belief that she would be an effective preservice and beginning teacher and would continue to improve with more teaching.

Table 4. Item 19 Score for Willa

item #	I	II	III	IV	V	BT
19R	I wonder if I will have the necessary skills to teach science.					
	3	4	4	4	4	5

It was a reading literacy program at her jobsite that Willa stated was the most helpful in terms of her teaching skills. For Willa, the significant difference in the training offered by the preservice program and her jobsite was not in the subjects covered, but in the timing of the information's application.

> (interview lines 76-85)
> "I think it is a lot different if you receive training as you go along (*Willa's referring to previous comments regarding the CRIS reading literacy program she participated in at her jobsite, Carson High School*), so you can incorporate it and look at exactly what you are doing, versus you are just going to school and then you are just doing teaching (*Willa's referring to her earlier comments regarding her preservice classroom experiences*). For me there is a huge difference. I couldn't go out that afternoon and use it (*her preservice training*) or go into the classroom that day and apply it. It is totally different."

In her statements regarding her beginning teaching year, Willa cited many examples of innovations or lessons she had successfully implemented. Willa ended her first year by stating she could teach pretty well and would improve with more teaching.

Table 5. Item 20 Score for Willa

item #	I	II	III	IV	V	BT
20R	Given a choice, I will not invite the principal to evaluate my science teaching.					
	4	4	4	4	4	4

During her preservice program, Willa did not mind anyone observing her - including the principal:

> (email communication lines E81-84)
> "I feel that I do the best job that I can consistently and I do this in any position that I hold. It did not matter that I was just beginning the program, I could do no more than to try my best, and if that is not good enough for someone or some establishment, it is better to find out sooner than later."

Because of her first year participation with a reading literacy program, Willa was observed more frequently than most of the faculty by the principal and stated she received very good reviews.

Table 6. Item 21 Score for Willa

item #	I	II	III	IV	V	BT
21R	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.					
	4	4	4	4	4	4

As time progressed, Willa continued to agree that she would teach science effectively, teach science better or as well as any subject, and actively find better ways to teach science: “Like physics concepts aren’t intuitive, so I think that you need to constantly, even within the class, try different things to see if it clicks with them” (interview lines 752-754).

Table 7. Total Category Score for Willa

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	23	25	24	24	24	27

Willa rarely marked 5’s on the STEBI items making up this category: “Because there is always a chance that I could be ineffective, even though I did not believe that I would be. Therefore, I do not like to choose the strongest option” (interview lines 47-48). For this group of items, her STEBI scores increased from a 23 (out of a possible 30) at the first STEBI administration to a 27 at the last STEBI administration during her beginning teacher year. Her cautious but positive statements regarding her science teaching efficacy beliefs are reflected in the increased STEBI scores for this classroom teaching practices category.

Stephanie’s Within Case Analysis

Table 8. Item 2 Score for Stephanie

item #	I	II	III	IV	V	BT
2	I will continually find better ways to teach science.					
	5	4	4	5	5	5

Stephanie's self knowledge (knowledge about her never being satisfied with an original form, about her always striving to improve herself) drove her to find better ways to teach science and led her to complete this STEBI item as she did.

> (email communication lines E4-6)
> "I just felt that, knowing myself, I would always be trying to find better ways of teaching. I don't believe that I will ever become the 'perfect' teacher. There will always be something for me to learn and work at. However, knowing myself,
> I know that I will never be satisfied with how things are; I will always try to improve myself."

Table 9. Item 3 & 8 Score for Stephanie

item #	I	II	III	IV	V	BT
3R	Even if I try very hard, I will not teach science as well as I will most subjects.					
	5	**5**	**5**	**5**	**5**	**5**
8R	I will generally teach science ineffectively.					
	5	**5**	**5**	**5**	**5**	**5**

Stephanie's beliefs were strengthened by support from her family and by the positive feedback from her students. She believed that her knowing the science content at a higher level than her students and her ability to explain it to them in more than one way were necessary components of her success as a science teacher. This belief held as long as Stephanie was talking about biology; physics was quite another matter:

> (interview lines 1576 – 1578; 838; 1376-1380))
> "The first piece of that is being able to, if you know the material really well, you can figure out multiple ways of explaining so that eventually you will hit on one that everyone understands.
>
> Well, physics is probably of the science that is at the bottom of my life.
>
> Give me the time so I can actually re-teach myself. It is probably not going to be as well-taught as if it was someone who actually majored in physics or had that background, because I am not going to have enough of a background to be able to pull in outside information to make the class more interesting. I would probably have to just following like the chapters say."

Table 10. Item 19 & 21 Score for Stephanie

item #	I	II	III	IV	V	BT
19R	I wonder if I will have the necessary skills to teach science.					
	4	**4**	**4**	**4**	**5**	**5**
21R	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.					
	4	**4**	**4**	**4**	**5**	**5**

In items 19R and 21R, Stephanie felt her scores rebounded to 5's as she gained more experience and got better and better at finding and revising science activities and more comfortable and confident with her abilities. At the end of her preservice program, Stephanie attributed her increased confidence in her teaching abilities to her students and feedback from her mentor teachers.

> (email communication lines E87-99)
> "The more I student taught, the more comfortable I became with my ability to teach. So towards the end I never wondered if I had the skills to teach, I knew that I did. As I moved thru the program, interacting w/ the students, & receiving feedback from my mentor teachers, my confidence in my teaching abilities improved.
>
> My first year of teaching helped to reinforce this idea. I never really found myself at a loss explaining a concept to a student, so I just felt that this statement didn't apply to me."

Table 11. Item 20 Score for Stephanie

item #	I	II	III	IV	V	BT
20R	Given a choice, I will not invite the principal to evaluate my science teaching.					
	3	**3**	**3**	**3**	**3**	**4**

Stephanie remained uncertain throughout her preservice program as to whether she would invite the principal to evaluate her. Although she questioned whether observing principals were there to see her teaching style or to judge her, Stephanie indicated she was more comfortable having a principal evaluate her during her beginning year:

> (interview lines 939-942)
> "Before, because I didn't have that much experience with principals in the school setting yet and know kind of what they might be expecting from me and what I can expect from them. Also, as a teacher… I am not so worried about screwing up in front of the principal if he does come into my class."

Table 12. Total Category Score for Stephanie

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	**26**	**25**	**25**	**26**	**28**	**29**

For this group of items, Stephanie's STEBI scores increased from a 26 (out of a possible 30) at the first STEBI administration to a 29 at the last STEBI administration during her beginning teacher year. Her strongly positive statements regarding her science teaching efficacy beliefs are reflected in the increased STEBI scores for this classroom teaching practices category.

Cross-Case Analysis of the Classroom Teaching Practices Category

The most frequently stated attribute in this cluster of classroom teaching practices beliefs was experience. For item 2, both Stephanie and Willa experienced a decrease, possibly due to an overestimation of their abilities that was tempered and lowered during their first practicum experience. Both participants experienced a rebound that they attributed to increased confidence originating from successful student and beginning teaching experiences. For item 8, Stephanie consistently and strongly agreed (indicated by a succession of 5's) that she taught science effectively, citing her past successful experience as a teacher before, during and after her preservice program. Willa did not have any prior teaching experience with children or science teaching and although agreeing she could teach science effectively – indicated her caution in belief by a succession of 4's.

The second most frequently mentioned attribute was subject matter knowledge. Both participants held baccalaureate degrees (Stephanie: biology; Willa: ceramic engineering) and felt confident in their level of science knowledge. Unlike Stephanie's expressed ability to explain science content to her students in a variety of ways, Willa's scores on items 3, 19 and 21 were perhaps lower due to her concerns of needing to learn how to communicate her science background to her students. Both individuals answered these items with specific grade levels in mind – middle school and high school. They also agreed that if they were to teach science subjects they considered difficult (Stephanie: physics; Willa: biology) that those difficulties would be due to their limited content knowledge in those areas.

The third and last theme that wove itself among this cluster of items was support. Stephanie repeatedly mentioned a variety of positive support sources: her family, her mentor teachers, her principal, and the faculty and students at Murray Hill High School. Willa had a similar teaching path in that, like Stephanie, she also returned to teach her first year at the site where she had done her student teaching. Unlike Stephanie, Willa did not feel supported:

> (interview lines 169; 254-260)
> Willa: I don't feel connected enough.
>
> Researcher: With the students?
>
> Willa: And also my peers.
>
> Willa: It is not just the classroom, but I don't feel there is a lot of motivation . . . I didn't feel like, at least at Carson, that there was a lot of collaboration between the teachers. It has a lot to do with the kids' behavior and the interaction or non- interaction with other teachers."

Interactions-with-Students Category

This category is comprised of items focused on the teacher's beliefs regarding her actions with and reactions to students. The STEBI self-efficacy items that are included in this category are:

Item 18 - I will typically be able to answer students' science questions.
Item 22 - When teaching science, I will usually welcome student questions.
Item 23R - I do not know what to do to turn students on to science.

Willa's Within Case Analysis

Table 13. Item 18 Score for Willa

item #	I	II	III	IV	V	BT
18	I will typically be able to answer students' science questions.					
	4	**4**	**4**	**4**	**4**	**4**

From her background of engineering and the amount of time she put into her lessons Willa believed she could answer students' questions:

> (email communication lines E65-69)
> “I have a strong science background and spend quite a lot of time on lesson preparation. I believe that I will be able to answer most science questions, especially ones pertaining to the lesson. If, however, I do not know something, I will look it up and get back to the students with the verified info. This has always been my working mode and so there is no reason that the answer to the question would fluctuate very much.”

Although there were times when she was reluctant to answer student's questions: “I am not a treasure trove of trivia. I don’t need to know off the top of my head how much current is in the average bolt of lightening” (interview lines 1250-1252).

Table 14. Item 22 Score for Willa

item #	I	II	III	IV	V	BT
22	When teaching science, I will usually welcome student questions.					
	4	**4**	**4**	**4**	**4**	**4**

When asked about her consistently agreeing that she welcomes student's questions, Willa stated: “I believe that questions stimulate discussion and learning, and so I would welcome them at any time of my career. I consistently try to prompt questions when I teach” (email communication lines E105-106). Willa also believed it was her job as a teacher to answer student’s questions:

> (interview lines-1266)
> “A lot of their questions I think aren’t just about the topic they are learning. It is more how is this topic related to the world outside or the real world. They can’t get that from their textbook or whatever. I think that is your job to answer those questions.”

Table 15. Item 23 Score for Willa

item #	I	II	III	IV	V	BT
23R	I do not know what to do to turn students on to science.					
	3	**3**	**3**	**4**	**4**	**4**

In response to her uncertainness regarding turning students on to science at the beginning of her preservice program, Willa stated: “I am not always certain what turns students on to science or anything else until I try something or teach a lesson” (email communication line E113). In terms of science activities, Willa stated: "They (*Willa is referring to her physics students*) liked, and I think they benefited from the hands on things. I don’t know why" (interview lines 1028-1029). Willa increased her response as she progressed through the program. When she ended her beginning year of teaching however, she wasn't overly confident in her ability to turn students on:

> (interview lines 1523; 1647-1650)
> “I still don’t know if I know what to do to turn them on to science. You do things to try to turn them on. We took a bunch of kids to the science museum. It is hard to even get them to go, some of them, to fill up the bus. I don’t know...”

Table 16. Total Category Score for Willa

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	**11**	**11**	**11**	**12**	**12**	**12**

Willa’s statement and scores indicated a confidence in her subject matter knowledge and her ability to utilize that knowledge to answer a student’s question. She also attributed her success in the area of student questions to her hard work and time she put into to making her lesson plans. For this group of items, Willa’s STEBI scores increased from an 11 (out of a possible 15) at the first STEBI administration to a 12 at the last STEBI administration during her beginning teacher year. Her increases in this category were limited by her uncertain beliefs in her ability to turn students on and are reflected in her statements and scores for this Interactions-with-Students category.

Stephanie’s Within Case Analysis

Table 17. Item 18 Score for Stephanie

item #	I	II	III	IV	V	BT
18	I will typically be able to answer students’ science questions.					
	4	**5**	**4**	**5**	**5**	**5**

Stephanie attributed her subject matter knowledge and her ability to use that knowledge to her confidence regarding her ability to answer students’ questions:

> (interview line 1380)
> “The thing about biology is that I feel comfortable enough in my knowledge that I can pull from various previous classes that I’ve had. . . or the newspaper. I can definitely flesh it out and make it more interesting."

Initially, Stephanie thought there might be times that she would not be able to answer a student’s question. As time passed however, Stephanie became:

(email communication line E 76-77)
“more confident with my abilities. And realizing that I may not know the answer right there, but I can find it for the student or help them to find it, which to me is still being able to answer the question."

Table 18. Item 22 Score for Stephanie

item #	I	II	III	IV	V	BT
22	When teaching science, I will usually welcome student questions.					
	5	**5**	**5**	**5**	**5**	**5**

Stephanie always encouraged students to ask questions: "I tell them that they need to ask any question that they may have (as long as it is a serious question, not one just to waste time!)" (email communication line E 102-104). She also strongly believed that: "a teacher has a responsibility to establish a climate in the classroom so that students feel comfortable with asking questions. (email communication lines E110-11). In reviewing her scores, Stephanie commented: "This is something that I feel strongly about and have never wavered in that. Though for me it should really say “always” not “usually” (email communication line E 105).

Table 19. Item 23 Score for Stephanie

item #	I	II	III	IV	V	BT
23R	I do not know what to do to turn students on to science.					
	4	**4**	**4**	**3**	**4**	**4**

Even if Stephanie was "the best teacher that I can be: entertaining and funny, smart and captivating" (email communication E116-118), she believed teachers don't always have control over a student's interest in science or learning: "The hesitation with this question (not being a 5) is that... if a student is not interested, I may not be able to change that; to reach them" (email communication line 125-129).

Stephanie attributed the 3 to winter term when the preservice teachers weren’t doing any student teaching. Once she got back into the classroom she was more confident in her abilities. Stephanie believed that to be an effective teacher you had to be able to turn students on. She believed she had achieved both during her beginning year:

(interview lines 1031-1037)
"I know it has been a good lesson if my third period class comes in and they are like: 'We heard we get to do this today. First period said they got to do this. So we hope we are going to get to do it, too... We are, right?’ ”

Table 20. Total Category Score for Stephanie

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	13	14	13	13	14	14

Stephanie attributed her STEBI scores in this interactions-with-students category to beliefs concerning her subject matter knowledge and her ability to relate her knowledge to her students in a welcoming, open and questioning classroom environment. For this group of items, Stephanie's STEBI scores increased from a 13 (out of a possible 15) at the first STEBI administration to a 14 at the last STEBI administration during her beginning teacher year. Her increases in this category were tempered by Stephanie's statements that she might not always know the answer to a student's question and that teaching "depends on the student being receptive, not just on the teacher's abilities" (email communication line 130).

Cross-Case Analysis of the Interactions with Students Category

Both Willa and Stephanie expressed confidence in their subject matter knowledge and in their beliefs in the importance of using that knowledge to help answer students' questions (item 18). Also indicated in their scores and through their statements, both participants stressed the importance of using everyday knowledge (Stephanie) and relating their subject to the students' world (Willa).

Stephanie's statements indicated that experience (or lack of) played a key part in some of her lower scores. When responding to why she had marked a score of 4 at the beginning of her preservice program: "Again, just that confidence thing" (email communication line E 71). With experience, Stephanie's score increased on item 18. When Stephanie wasn't teaching and gaining classroom experience, she also marked a 3 on turning students on to science. Unlike Willa who never mentioned experience in her statements for this category, Stephanie attributed her increased STEBI score for this item to her increasing experience.

Also noteworthy in this section is Stephanie's expansion of the definition for "answering students' questions." Rather than only answering the STEBI 18 item based on her knowing the answer when asked, Stephanie expanded her interpretation of answering to include helping her students to find the answer.

The item in this category that was consistently the lowest in Stephanie's STEBI surveys was item 23: I do not know what to do to turn students on to science. The attributes given by both participants, however, differed. For Willa, her confidence in turning students on was related to her personal knowledge "I still don't know if I know what to do to turn them on to science" (interview line 1523). For Stephanie, her confidence and score were influenced by her knowledge regarding her students: "(*I'm*) just coming to the realization that I don't always have control of why a student isn't interested in science or learning. I may not be able to reach some of them" (email communication E125-126).

Science Content Knowledge Category

This category is comprised of items focused on the teacher's beliefs regarding her science content knowledge. The STEBI self-efficacy items that are included in this category are:

Item 5 - I know the steps necessary to teach science concepts effectively.
Item 12 - I understand science concepts well enough to be effective in teaching elementary science.

Willa's Within Case Analysis

Table 21. Item 5 Score for Willa

item #	**I**	**II**	**III**	**IV**	**V**	**BT**
5	I know the steps necessary to teach science concepts effectively.					
	3	**4**	**4**	**4**	**4**	**4**

Although confident in her knowledge of science concepts, Willa was initially uncertain concerning her knowing the steps to teach science: "When I first began classes at OSU, I was not certain if I knew how to teach (I did not, that is why I was in class)" (email communication lines E19-20). Willa's scores on this item rose as she progressed through her preservice year: She attributes her preservice program for helping her in this area:

> (interview lines 979-982)
> "I think part of doing the teaching program did was (*to*) help me to identify what steps are, like what do you need to – kind of like scaffolding type of stuff. You need to have some base to learn stuff on. I didn't feel like I could recognize those things at the beginning."

Willa ended her beginning year with the continued belief that: "a lot of science – at least topics, especially in physics, need to be taught sequentially, because everything is built upon everything else" (interview lines 929-931).

Table 22. Item 12 Score for Willa

item #	I	II	III	IV	V	BT
12	I understand science concepts well enough to be effective in teaching elementary science.					
	4	**4**	**4**	**4**	**4**	**5**

Willa stated that her background in science was strong and that she could: "definitely be able to teach (*the*) more basic concepts" (email communication E 52-53). During her pre-service she did an ocean sciences unit with Kindergarteners and indicated this as the experience which led her to continue indicating agreement with this item. Willa ended her year believing elementary school teachers to be: "always science deficient" (interview line 1130). She considered herself capable of doing the more basic concepts (referred to earlier in this paragraph) because she found:

> (interview lines 1130, 865-867)
> "biology pretty, I mean, if you read it and you have those little... they sort of name things and classify things, and you put things in biomes or this or that. You identify what that is and have a picture and have kind of like a definition of it."

Table 23. Total Category Score for Willa

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	**7**	**8**	**8**	**8**	**8**	**9**

Subject matter knowledge played a dominant theme in both of these items. Willa was confident in her knowledge of the science concepts, and, even in areas where she was not as confident, she believed she could teach herself the necessary science content for an elementary science class. She was initially uncertain that she knew how to teach and her STEBI score for item 5 is initially a 3. She credited her preservice program for showing her the importance of scaffolding knowledge for her physics students. She also referenced an earlier elementary practicum experience with positively influencing her belief in doing elementary science. For this group of items, Willa's STEBI scores increased from a 7 (out of a possible 10) at the first STEBI administration to a 9 at the last STEBI administration during her beginning teacher year.

Stephanie's Within Case Analysis

Table 24. Item 5 Score for Stephanie

item #	I	II	III	IV	V	BT
5	I know the steps necessary to teach science concepts effectively.					
	3	**4**	**4**	**4**	**5**	**3**

Echoing the concerned voices of many new preservice teachers, Stephanie was initially uncertain as to her knowing the steps to effectively teach science concepts. At the end of her preservice program, however, her self-efficacy had rebounded: "Going into the year I thought. . . I don't know everything yet. I don't know all the steps but I'll learn them. Then at the end of my student teaching I am like, yeah, I got this" (interview lines 845-852).

However, at the end of her first year teaching, Stephanie was again uncertain, but not with her confidence regarding knowing the steps to science teaching:

> (interview lines 1025-1036)
> "Now that I have been teaching on my own, I realize that, you know, I don't know if there is necessarily any set steps to teaching science. I think there probably are lots of different ways to teach science and they may not necessarily all include the same steps."

Table 25. Item 12 Score for Stephanie

item #	I	II	III	IV	V	BT
12	I understand science concepts well enough to be effective in teaching elementary science. (***N.B.*** the phrase "*high school or middle school" was mentally substituted for the word "elementary" by Stephanie during all of the STEBI administrations below.*)					
	5	**5**	**5**	**5**	**5**	**5**

During her interviews, when asked about her possible mental substitution of middle school or high school biology for the word elementary in item 12, Stephanie replied: “I think so, because I think that is the first time I’ve heard the elementary part of it… did it actually mean like elementary school, as in 1 through 5?” (interview lines 1633, 1634 and 1659). The researcher asked her to retrospectively answer this STEBI item using the “elementary” wording. Her answers are seen below.

Table 26. Item 12 Revised for Stephanie

item #	**I**	**II**	**III**	**IV**	**V**	**BT**
12	I understand science concepts well enough to be effective in teaching elementary science. (***N.B***. *the below scores represent Stephanie’s responses to item 12 using the original “elementary” wording.)*					
	3	**3**	**4**	**4**	**4**	**4**

Stephanie believed effective science teachers knew their subject matter and could explain it to students. She attributed an initial uncertainty to her having no teaching experience in the younger grades. Although Stephanie did gain experience through an early preservice practicum with 6th grade and subbed in 2nd, she believed her effectiveness was limited by elementary students’ short attention spans, behavioral issues and her own communication skills:

> (interview lines 1689 – 1703)
> “You can’t explain it normally in your own language. It is a smaller step from college to high school/middle school than from college to elementary. You are working with, usually, more background knowledge. They (*middle/high school students*) have lived longer. They have been in more classes. They have a certain level. You can use the word mitosis and they know what you are talking about. You use the word mitosis with elementary kids and they are like: ‘Huh? What’s that?’ ”

When asked if she could teach elementary science, Stephanie emphatically responded: “Oh, no, no, no, no! Elementary is a whole other world. I subbed in elementary. It is much harder” (interview lines 1665-1677).

Table 27. Total Category Score for Stephanie

item #	**I**	**II**	**III**	**IV**	**V**	**BT**
TOTAL CATEGORY SCORE	**8**	**8**	**9**	**9**	**9**	**9**

Stephanie's responses to both of these items in the science content knowledge category are generated from teaching experience and self knowledge. Based on her statements, Stephanie was disagreeing with the wording of these STEBI items rather than experience lesser confidence in her science teaching ability. In item 5, rather than questioning her knowledge or ability, Stephanie was philosophically questioning the existence of the steps necessary to teach science effectively. In item 12, a similar difference of opinion occurred due to Stephanie's belief that effective science teaching hinged on knowing the science concepts *and* being able to communicate with her students. For this group of items, Stephanie's STEBI scores increased from a 4 (out of a possible 10) at the first STEBI administration to a 5 at the last STEBI administration during her beginning teacher year.

Cross-Case Analysis of the Science Content Knowledge Category

Similar to her performance in the previous two STEBI categories, Willa again increased her scores on the 2 items making up the science content knowledge category. She had confidence in her knowledge of the science concepts, in her ability to teach herself elementary science content when necessary and in the necessity of teaching that knowledge in scaffolded steps, especially in the area of physics. Willa attributed her early practicum experience teaching oceanography to an elementary class to her belief that she could effectively teach elementary science.

Experience also factored into the STEBI scores of Stephanie on items 5 and 12. Stephanie did not believe she would be an effective elementary science teacher. She too had had experience as a preservice practicum teacher and as a substitute teacher and found that translating her knowledge of science concepts to this level of student was very hard for her to do. With regard to steps in science teaching, Stephanie did not share Willa's confidence in their necessity or even their existence.

Science Experiments Category

This category is comprised of items focused on the teacher's beliefs regarding her behavior during science experiments. The STEBI self-efficacy items that are included in this category are:

Item 6R - I will not be very effective in monitoring science experiments.
Item 17R - I will find it difficult to explain to students why science experiments work.

Willa's Within Case Analysis

Table 28. Item 6 Score for Willa

Item #	I	II	III	IV	V	BT
6R	I will not be very effective in monitoring science experiments.					
	4	**4**	**4**	**4**	**4**	**4**

Even though Willa had not completed any coursework or been a science teacher in a classroom, she initially agreed she could monitor science experiments based on her lab experience and background as an engineer:

(interview lines 1060-1063)
"If you spend a lot of time working in the lab like in training other people - I worked at a lab at ICFab, even - you have safety issues there. I have taken a lot of chemistry, a lot of labs. All this hair business, or goggles, you wear things, I knew that I needed to do that."

She continued to mark 4's on this STEBI item and did not mark a 5 because: "I guess that I felt that there is always some room for error and there was a chance that I would not monitor an experiment well" (email communication E34-35).

Table 29. Item 17 Score for Willa

item #	I	II	III	IV	V	BT
17R	I will find it difficult to explain to students why science experiments work.					
	4	**4**	**4**	**4**	**4**	**4**

Willa agreed she could explain to her students why science experiments worked: "Like once I have done it myself, I am pretty comfortable with explaining it in lab settings and just with experimentation" (interview lines 1049-1051). Willa attributed the occurrence of her remaining scores to her: "background and ability to learn in order to fill in any explanation gaps. I am not certain why I did not change to 'strongly disagree' except, if I remember correctly, I rarely chose that option" (email communication E 58-60).

Table 30. Total Category Score for Willa

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	**8**	**8**	**8**	**8**	**8**	**8**

Willa attributed her STEBI answers for these two items to her college science coursework with labs and to her time spent in engineering manufacturing labs. She felt her subject matter knowledge and extensive background in lab settings would provide the knowledge for effective monitoring, and she was confident that she could learn the content if any explanation gaps did occur in her classroom during a lab.

Stephanie's Within Case Analysis

Table 31. Item 6 Score for Stephanie

item #	I	II	III	IV	V	BT
6R	I will not be very effective in monitoring science experiments.					
	4	**4**	**5**	**4**	**5**	**4**

In the beginning, Stephanie felt that she would be:

(email communication E 18-20)
"fairly good at keeping an eye on my students during science experiments. Perhaps not great (that's why it isn't a five) but pretty good. I felt that I am a pretty observant person; that I wouldn't be the type to just turn them loose and not watch them."

Her confidence and STEBI scores generally improved with her preservice experiences: "I thought after my student teaching experiences that I would be pretty good at keeping an eye on students. I supposed I was feeling a bit cocky; thinking I could keep a good eye on my students all the time" (email communication E20-22). However, after a lab that occurred during her beginning teaching year which involved a particular troublesome group of boys, matches, wax paper and fireballs, Stephanie became: "a bit more realistic. No matter how hard I try, some things may go wrong (i.e. the flaming wax paper), so it was back to a 4" (email communication E20-22).

Table 32. Item 17 Score for Stephanie

item #	I	II	III	IV	V	BT
17R	I will find it difficult to explain to students why science experiments work.					
	4	**4**	**4**	**5**	**5**	**4**

At the beginning of her preservice program Stephanie had confidence in her abilities to explain, but she also worried: “that I was being a little cocky; that I would have a little trouble sometimes. That there would be times, that I would have trouble explaining something to a student” (email communication E63-64). As she gained experience through student teaching, she didn’t believe she would: “ever attempt an experiment that I didn’t understand” (interview line 1796) and, she thought: “no problem, I can handle anything” (email communication lines E63-64). According to Stephanie, she became more realistic towards the end of her beginning year of teaching, and she lowered her score to a 4. There was the failed jello enzyme experiment which still baffled her at the time of her last interview and one other aspect that Stephanie attributed to tempering her beliefs on this item:

> (interview lines 1823-1825, email communication lines E65-66)
> “(*I am*) more realistic after my first year of teaching and realized that there may be some times where something happens that I can’t explain. There may be times that I have trouble explaining things to a student because I may have trouble seeing where the student’s block is and overcoming it.”

Table 33. Total Category Score for Stephanie

item #	I	II	III	IV	V	BT
TOTAL CATEGORY SCORE	**8**	**8**	**9**	**9**	**10**	**8**

In both items Stephanie started her preservice program fairly high. She believed she was observant in lab settings and could explain most experiments to her students. Student teaching saw gains in her experience and in her confidence to monitor and explain labs. At the end of her beginning year, Stephanie lowered her scores on these items attributing the shift to the reality of the lab setting and that although she may be observant, she might not necessarily see the explanation to help a student understand the lab.

Cross-Case Analysis of the Science Experiments Category

Both participants had extensive lab experience both as students and as past employees, yet only Willa consistently mentioned it in relation to these two items. Both increased in their beliefs regarding experiments as they gained preservice teaching experience, yet only Stephanie decreased her scores at the end of her beginning year of teaching. Willa, echoing previous category scores, remained cautiously and consistently positive that she would be able to monitor and explain experiments. Stephanie, perhaps overconfident at the completion of her preservice program, also agreed she could be effective in a lab setting, but she no longer used wax paper: “to keep the candle wax off the table” (interview line 1802).

General STEBI Score Trends

Willa and Stephanie entered into the science teaching professions for different reasons: Willa because she thought a teaching schedule would suit her desires to fit in more time with her son and be in the community more; Stephanie because she had enjoyed working in a university science setting as a teaching assistant and wanted to help young people find their path in life. Irrespective of their differing, initial reasons, both successfully completed the MAT program, were granted licensure and secured jobs as beginning teacher at the high schools where they had student taught. In comparing their beliefs at the beginning of their MAT program and at the end of their first year as beginning teachers, both participants indicated that they had increased their science teaching self-efficacy beliefs as their survey totals below show. Not only were greater science teaching self-efficacy gains seen in Willa’s data set, but Willa’s scores had moved her from the medium to the high STEBI group at the end of her beginning year of teaching.

Table 34. Survey Administration

	I	**II**	**III**	**IV**	**V**	**BT**
Willa STEBI TOTAL	**48**	**52**	**51**	**52**	**52**	**56**
Stephanie STEBI TOTAL	**53**	**55**	**55**	**56**	**61**	**58**

(STEBI total score possible = 65)

The above findings contradict the majority of results presented in the science teaching self-efficacy research. Conducting a study limited to within a preservice timeframe, Cantrell, Young, & Moore (2003) found that science teaching self-efficacy belief scores increased significantly ($F(2,253) = 10.10$; $p < .001$ from entrance into the teaching program until the beginning of student teaching where self-efficacy leveled off. In longer studies dealing with preservice and beginning teaching years, science teaching efficacy decreased as individuals progressed from their preservice to beginning teacher year (Ginns & Watters, 1999; Soodak & Podell, 1997; Woolfolk Hoy & Spero, 2005).

To explore the possible reasons for this study's contrasting findings, the antecedent survey and participant attribute data (from their interviews, emails and letters) are presented. The table below shows the longitudinal changes in Willa and Stephanie's STEBI scores during their preservice and beginning year as teachers. The counts are organized on the four categories used in the results (see Appendices) and represent changes within the participant's STEBI I, V and BT survey items making up that particular category.

Table 35. Longitudinal Changes in STEBI Scores

	Increase		No Change		Decrease	
	W	S	W	S	W	S
Classroom Teaching Practice	3	3	3	3	-	-
Interactions with Students	1	1	2	2	-	-
Science Content Knowledge	2	1	-	-	-	1
Science Experiments	-	-	2	-	-	2
TOTAL (N = 26, the combined items of 13 STEBI items for Willa and Stephanie)	**11**		**12**		**3**	

(W = Willa; S = Stephanie)

Science Teaching Self-Efficacy Sources

To summarize the longitudinal changes in Willa and Stephanie's STEBI scores during their preservice and beginning year as teachers, Bandura's four sources of self-efficacy will be utilized:

1) mastery experiences – an individual's past successes and failures;
2) vicarious experience – skill in question is modeled by someone considered competent by and comparable to the individual;

3) verbal/social persuasion - encouragement received from a knowledgeable source and
4) physiological and affective states – somatic information conveyed by physiological and emotional arousal

Science teaching self-efficacy researchers have frequently discussed the presence or absence of these self-efficacy sources in their conclusions (e.g., Bleicher, 2006; Ginns & Watters, 1999). Others have intentionally utilized the self-efficacy sources as their research framework (e.g., Brand & Wilkins, 2007; Mulholland & Wallace, 2001). This study employs the framework as a method to help summarize the results for the reader.

Mastery Experiences

As in other studies (Cantrell et al., 2003; Ginns & Watters, 1999) both participants attributed the majority of their increase and levels in science teaching self-efficacy beliefs to their teaching experiences. Increases or no change in science teaching self-efficacy beliefs were seen in 23 out of the 26 STEBI items. The increases and no changes were combined because for both participants "no change" STEBI scores were either 4's or 5's and showed consistent agreement with the STEBI items. Willa indicated 8 increases or no changes in teaching self-efficacy beliefs: 3 in the classroom teaching, 2 in the interactions with students, 2 in the science content knowledge and 1 in the science experiment categories. She attributed the majority of her increases and no changes in science teaching self efficacy to the teaching experience she gained during her preservice and beginning teaching year.

Stephanie indicated 9 increases or no changes in teaching self-efficacy beliefs: 5 in the classroom teaching, 3 in the interactions with students and 1 in the science content knowledge categories. Stephanie attributed her increases to her experiences gained during her preservice and beginning teaching year and to her prior teaching experiences as a university teaching assistant. Stephanie attributed her lower scores to situations where she had limited or no experience (i.e. she was uncertain in her scoring because she had no experience with being evaluated by a principal) and attributed her increases to the teaching experience she gained during her preservice and beginning teaching year.

Only Stephanie exhibited decreases in her three of her STEBI scores and those decreases were due to unsuccessful experiences. Both of the items in the Science Experiment category experienced increases as her preservice program progressed and decreases at the end of her beginning year of teaching. Stephanie attributes this rise and fall to her being too: “cocky” (email communication lines E20, 60) in regards to her monitoring her students during a lab and explaining a lab experiment. Incidences involving fireballs and unexplainable, failed enzyme experiments were attributed by Stephanie to her readjustment of her beliefs and the lowering of her scores to: “more realistic” levels (email communication line E65). Also influencing Stephanie’s lowering of her score on item 17 (explaining lab experiments to students) was her realization that she was sometimes limited and had “trouble seeing where the student’s block is and overcoming it” (email communication E66).

Although both participants mentioned the successful experiences as positive influences in their interviews, Willa’s statements had a different emphasis. The majority of her experience statements both for the preservice and beginning year of teaching focused on the idea of the necessity of gaining experience: “I feel that I am a good science teacher and would improve with more teaching” (letter communication line L14). Both participants believed they would be good science teachers. Stephanie based this belief on her actual past experiences. Willa did as well, but to a lesser extent. For Willa, her belief of being a good science teacher seemed to be based more on future teaching experiences yet to come.

The second most commonly mentioned influence on the participants’ science teaching self-efficacy scores was the subject matter knowledge gained from their college coursework and their previous jobs. Throughout the STEBI survey administrations, interviews, emails and letters, both participants strongly and consistently believed in the importance of their subject matter background. This finding is not similar to the science teaching self-efficacy research of Enochs, Scharmann & Riggs (1995) and Ramey-Gassert, Shroyer & Staver (1996) in which they found negative correlations between science teaching self-efficacy beliefs and the number of college science courses taken. A possible explanation for these conflicting findings may have to do with the samples worked with: for this study – MAT, high school science teachers with a degree in science; for Enochs, Scharmann & Riggs (1995) and Ramey-Gassert, Shroyer & Staver (1996) elementary teacher, who did not necessarily have the accompanying science coursework that goes with a science degree.

With no exception, this study's participants answered all the STEBI items with their respective subject background in mind: Willa - engineering and physics; Stephanie - biology. When asked to step out of those mindsets and entertain the idea of teaching other secondary sciences (Willa - biology; Stephanie - physics), both participants stressed their hesitation to do so due to their lack of college classes and subject matter background.

In regards to teaching knowledge, for Willa, teaching knowledge was provided by the MAT program and an implemented reading literacy program and inservice professional development sessions at her beginning teaching jobsite:

> (email communication lines E20-21, interview lines 131-134; letter communication line 95)
> "The (*MAT*) courses provided me with a way to learn how to communicate what I know. In this CRIS strategy (*the reading literacy program*), nothing is new. It is just putting together a lot of things that a lot of different programs. As we have gotten into the year, you can take things and try to apply it or use it. That has been really helpful. The training emphasis for inservices was always on teaching and teaching method."

Stephanie felt her previous teaching background as a university teaching assistant reinforced her beliefs regarding her teaching skills:

> (interview lines 2266-2273)
> "But my experience was a lot different from a lot of other people in my cohort. I had already been teaching at a college. I felt like there are certain things that I have already done that I know that I can do. I know that I can write an exam. I know that I can create a PowerPoint presentation. I know that I can communicate certain concepts to people."

Although age has been included in previous science teaching self-efficacy research, it has been mainly treated as a descriptive piece of data describing the sample (e.g., Raudenbush, et al., 1992). Both participants were older than average students – Willa was 45 and Stephanie 32 years old. Both believed they knew themselves and their strengths and had left previous employment experiences to become teachers. In comparing themselves to their younger cohort members, both Willa and Stephanie attributed their age as a positive factor in their enrolling in the MAT and to their wanting to be teachers:

(letter communication lines 50-51)
Willa: "I was 45. I know what I am capable of and know that I could do."

(interview lines 2280-2281, 2287)
Stephanie: "I was starting out the program at 30, not 23 where a lot of them were (*Stephanie is referring to the younger MAT members of her cohort*). I had already tried different career paths and realized they were not for me. I really felt that I had finally found that place that I fit, that I had been searching for so long."

One last source of mastery experiences was found in Willa's prior employment. Willa worked as a failure analysis engineer prior to her entrance into the MAT program. A failure analysis engineer investigates subcomponent reliability and uses fault isolation and physical analysis to determine root causes of a failure and performs subsequent analysis on the new, replacement subcomponent. Her job was to find weaknesses that could become failures in computer components. This work focus perhaps influenced her statement when she agreed to inviting principal evaluations because: "it is better to find out sooner than later" if you are a good teacher (email communication line E84). Her reluctance in marking 5's for strongly agreed on the STEBI items also might be attributed to her engineering background:

(email communication lines E36, 47-48)
"I guess that I felt that there is always some room for error. There is always a chance… even though I did not believe that I would be (*ineffective*). Therefore, I did not like to choose the strongest option."

Vicarious Experience

Vicarious experiences involve a skill in question being modeled by someone considered competent by and comparable to the individual. This source differed in terms of occurrence for the participants: Willa never mentioned it at all; Stephanie positively mentioned it once:

> (interview lines 220-228)
> "There were a few times where I would say, okay, I've got this new activity I came across. I am going to try it. He (*Stephanie's mentor teacher*) would be like, okay. Then it would not work out. Then he would be like, he is like, okay I'll try it my period and then he would make changes based on what he had seen that didn't work out with me, and it would be better. I would be like, dang."

Verbal/Social Persuasion

Both participants mentioned aspects of verbal/social support in response to questions concerning their STEBI scores. Stephanie strongly attributed increases in her responses to the social support she received from people who gave her feedback and encouragement: her family, mentors, jobsite faculty and her students. Stephanie mentioned the positive effects of social support fourteen times in the data collected for this study.

Willa also mentioned social support, but in her case it was the lack of it.

> (interview lines 254, 267, 273, 323, 658-659)
> "I don't feel connected enough. There are eight science teachers here. Six of them are biology and the chemistry teacher is really biology. With biology teachers I am having some issues with... It is self perpetuating… We are a biology-centric school. Also I like working with people I can depend on, and I didn't feel like, at least at Carson High School, that there was a lot of collaboration between the teachers"

Stephanie's responses were in alignment with researchers who have pointed to the importance of social support (Ginns & Watters, 1999; Ramey-Gassert et al., 1996; Soodak & Podell, 1997; Woolfolk Hoy & Spero, 2005). Willa's perceived lack of support did not seemingly influence her STEBI scores and might call into question the connection between lack of support and decreasing self-efficacy beliefs.

Physiological and Emotional Arousal

The source of self-efficacy originating from physiological and emotional arousal that is then manifested by the body is the least cited in the literature (e.g. Bleicher, 2006) and in this study. Bandura states that this source of efficacy is created by individuals: "in coping with threatening situations" (Bandura, 1977, p. 198). Individuals conjure up fear-provoking thoughts about their ineptitude and rouse themselves to: "elevated levels of anxiety that far exceed the fear experienced during the actual threatening situation" (p. 199). Neither Willa nor Stephanie ever exhibited in their words or in their body language fear and anxiety. This lack of occurrence could be due to the retrospective nature of the interviews – if there had been fears, they were most likely outweighed by the successful completion of their first year of teaching. This lack could also be due to the participants' withholding this personal information and their wish to maintain an objective separation between the researcher and themselves. The participants did have concerns about how they would handle difficult teaching situations: "I was wondering if I would be able to find those better ways. I knew that I wanted to, but maybe it would be a harder process than I thought…" (Stephanie interview lines 1215-1216). For Willa and Stephanie, they both recognized they had areas in their teaching that might need improvement. Both of them, however, recognized those areas without obvious fear and proceeded to view a potentially threatening experience as an opportunity to improve themselves as teachers.

STEBI Validation and Response Process

This study documented the levels and changes of the participants' science teaching self-efficacy beliefs as they progressed through their teacher education program and transitioned into their first year of teaching. This study was also intended to be a validation study of the STEBI constructs. The AERA's *Standards for Educational and Psychological Testing* (American Educational Research Association, 1999) defined the term "construct" as any concept or characteristic that a test is designed to measure. Thus, STEBI Item 5: "I know the steps necessary to teach science concepts effectively" (Riggs & Enochs, 1990, p. 636) would be considered a construct. Construct validity is not a property of a test, but rather the meaning of the test scores. Current AERA Standards consider all validity as construct validity and define it as an investigative process through which constructs are carefully designed, data and evidence are gathered and assembled to form an argument either supporting or refuting some very specific interpretation of assessment scores (AERA 1999). The validity of the relationship between the scores and meaning: “is an overall evaluation judgment… scores are a function not only of the items or stimulus conditions, but also of the persons responding” (Messick, 1995, p.741) Construct validity is made up of scores, the rationales for those scores, and the trustworthiness of those rationales to explain the scores

To gather those rationales, this study used questions that focused specifically on the participant’s score levels and score changes for each STEBI item. Through the use of direct probes, this study sought to add clarity to the STEBI instrument by utilizing another, more specific, level of construct validation. In general terms, the scores of the thirteen STEBI items were validated by the participants’ statements. To limit the possibility of leading the witness, specific and open ended questions were asked for each STEBI item. Assessment data (e.g., the STEBI scores presented in this study) are more or less valid for some very specific interpretation at a given point in time and only for some well defined population (Downing, 2003). It was never the intention of this study to be generalizable beyond the two participants. However, in using two participants rather than one, trends and patterns were found in their independent responses which can be used as further evidence that the STEBI scores were validated by the participants’ statements.

Below, in Table 36, the 13 STEBI items can be found organized by category for each participant. For each STEBI item, a participant was asked to elaborate on the origin of their STEBI scores for three distinct time periods: 1) at the very beginning of their teacher education program (survey administration I), 2) during their teacher preparation program (survey administrations II -V) and 3) at the end of their beginning year (survey administration BT). As such, each item had 6 opportunities to be validated by the participants’ statements. Construct validation was indicated by a “Y” in the below table and represents occurrences in which the particular STEBI item score was perceived by the researcher to be in total alignment with the participant's responses. An "N" was utilized to represent occurrences in which the particular STEBI item score was perceived by the researcher to not be in total alignment with the participant's responses.

Table 36. STEBI Instrument Validity

		Willa			Stephanie			STEBI Validated
		Survey administration			Survey administration			
STEBI Category		I	I-V	BT	I	I-V	BT	
Classroom Teaching Practices	Item 2	Y	Y	Y	Y	Y	Y	100 %
	Item 3	Y	Y	Y	N	N	N	50%
	Item 8	Y	Y	Y	Y	Y	Y	100 %
	Item 19	Y	Y	Y	N	N	N	50%
	Item 20	Y	Y	Y	Y	Y	Y	100%
	Item 21	Y	Y	Y	Y	Y	Y	100%
Interactions with Students	Item 18	Y	Y	Y	Y	Y	Y	100%
	Item 22	Y	Y	Y	Y	Y	Y	100%
	Item 23	Y	Y	N	Y	Y	Y	83%
Science Content Knowledge	Item 5	Y	Y	Y	Y	Y	N	83%
	Item 12	Y	Y	Y	N	N	N	50%
Science Experiments	Item 6	Y	Y	Y	Y	Y	Y	100%
	Item 17	Y	Y	Y	Y	Y	Y	100%
Average STEBI Construct Validity								86%

In general terms, the scores of the thirteen STEBI items were validated by the participants' statements 86% of the time. For the items comprising the Classroom Teaching Practices category, Willa's responses validated all of her STEBI item scores for this category. The validity of Stephanie's responses in this category was variable and based on her interpretation of the word "science" in the STEBI items. When her interview comments for items 3 and 19 were reviewed, Stephanie's scores were completely supported by her statements. However, when the interview shifted to physics being the "science" under discussion, Stephanie's scores were not validated by her statements.

For the items in the Interactions with Students category, Willa's questioning statements regarding her possessing the ability to turn students on to science were not validated and reflected in her scores of agreement (see pg. 73).

The category with the least validation was the Science Content Knowledge Category. Willa's STEBI scores were validated by her responses. Stephanie's responses failed to validate her scores on the two STEBI items making up this category – for two very different reasons. For item 5 which deals with knowing the steps of effective science teaching, Stephanie's score went from a 5 at the end of her preservice year to a 3 at the end of her first year of teaching. A STEBI score of three would normally be interpreted as Stephanie being uncertain that she knew the steps. From her responses however (see p. 79), Stephanie was uncertain as to the reality of those steps. The STEBI score, by itself, failed to capture this higher level thinking and was consequently not validated by Stephanie's almost existential response. Similar to her imposition of the word "biology" for science, Stephanie automatically, and initially, substituted middle school/high school when answering item 12 which dealt with elementary science. Her middle school/high school responses did not validate the STEBI scores for this elementary school focused item.

In the Science Experiments Category Willa's and Stephanie's STEBI scores were completely validated by their responses.

Response process is defined as: "evidence of data integrity such that all sources of error associated with the test administration are controlled or eliminated to the maximum extent possible" (Downing, 2003, p. 834). The remaining paragraphs of this section, although not attempting to discuss *all* sources of error, does attempt to present areas in which the construct validity of the STEBI was threatened. The first threat considered is construct underrepresentation: the assessment is too narrow and fails to include important dimensions or facets of the construct (Messick, 1995). Stephanie's answer to item 5 where she questioned the existence of steps in teaching science is an example of construct underrepresentation. The STEBI was not designed to capture such higher order thinking. The use of Stephanie's statements in this particular situation gave a fuller and more valid explanation of why she had marked a 3 at the end of her beginning year. She was not suffering from a lack of confidence in herself. She was experiencing a new dimension in her thinking that the STEBI failed to capture. This finding suggests that the existence of lower STEBI scores may not necessarily be an indication of lesser science teaching self-efficacy beliefs.

The second threat to the construct validity was seen in construct-irrelevance variance: the assessment is too broad; other distinct constructs affect the responses (Messick, 1995). This threat occurred with item 12: which dealt with understanding science concepts well enough to be effective in teaching elementary science. The STEBI was originally designed to be given to elementary science teachers. It has, however been given to other levels and types of preservice teachers (Lockman, 2006; Rubeck & Enochs, 1991). In this study, the analysis plan of the STEBI included the possibility of removing the elementary focused item 12 if both teachers answered it as the high school science teachers that they were. Such was not the case - Willa answered it with the mindset of an elementary teacher; Stephanie imposed her own distinct construct onto the item and answered as the high school biology teacher she was. During the introduction given at the STEBI administrations, item 12 and the elementary wording were not mentioned. Stephanie was asked to retake item 12 answering it as an elementary teacher, and her statements were analyzed and presented. Without interview statements, the item 12 anomaly would not have been caught. Construct-irrelevance variance was again seen in Stephanie's superimposition of the construct "biology" for the word science in STEBI items 3, 12 and 19. These findings suggest the importance of determining which class and/or subject area a participant is thinking about when they are answering the STEBI items. Without this specific information, generalizations of participants' science teaching self-efficacy beliefs may lead readers to the wrong conclusions.

Both Stephanie and Willa had issues with the way the STEBI survey was administered. The STEBI was administered in a packet with two other surveys. It was a large packet, Stephanie commented: "I think probably all of us, when we got them, were just so focused on: 'holy crap, this is long!' " (interview line 22194). Willa also pointed out that she didn't always remember why she marked her STEBI items the way she did:

> (interview lines 1685-1689)
> "You have to remember, it was at the end of the day. We had often worked a full day in the classroom. We were tired. Some of us, like me, had already traveled to OSU and still had to drive home."

Conclusions and Implications

This study investigated the science teaching efficacy beliefs of preservice science teachers have at various points of time in during their teaching preparation program and first year as beginning teachers. Unlike many studies, it was longitudinal in design, utilized six administrations of the STEBI and utilized open ended, yet focused interview questions focused on the levels and changes in the STEBI item scores. Interview questions also probed for the meaning participants gave to the mark they make on the Likert scale in responding to items about science teaching self-efficacy. By using participants' responses, a construct validity rate of 86% was achieved for the STEBI. Total construct validity was not achieved mainly due to participant "mis"interpretation of the STEBI item wording: e.g., the participant superimposing "biology" for "science" in the STEBI item. Although Willa did have one occurrence in which her score did not align with her statements, the remaining occurrences in which the STEBI items were not validated originated with Stephanie. These events suggest that STEBI scores should be viewed with caution and with knowledge of the subject matter and class that the participant is basing their survey responses on. Even with this knowledge however, item 5 ("knowing the steps to teach science effectively") also suggests the usefulness of coupling a STEBI survey with an interview. Without specifically asking Stephanie about her item 5 response, her STEBI score decrease (a five followed by a three) would have been seen as a possible decrease in confidence. This study's interview revealed that Stephanie's lower score was not due a lowering of her science teaching self-efficacy beliefs but to her higher level thinking regarding the existence of such science teaching steps.

The findings of this study do not support the literature showing decreases in science teaching self-efficacy beliefs during the preservice year (e.g., Mulholland & Wallace, 2001) and during their first year as beginning teachers (e.g., Ginns & Watters, 1999). Both participants experienced STEBI score gains through the duration of this study. Stephanie began and ended in the high STEBI scoring category; Willa started in the medium category and ended the study in the high category. When looking at their STEBI scores, both participants attributed the majority of their scores to teaching experiences as preservice and inservice teachers. Participants stated that successful teaching experiences influenced them to raise their STEBI scores, whereas unsuccessful teaching experiences influenced them to lower their STEBI scores. This study's findings support the calls from researchers urging teacher education programs to provide preservice teachers with multiple and successful teaching experiences.

As high school biology and physics teachers, both participants also stressed the importance of their subject matter knowledge in positively influencing their science teaching self-efficacy belief scores. For these participants, this knowledge originated from their coursework (both held baccalaureate degrees in science) as well as prior employment experiences. Both reported that they would feel uncomfortable teaching other science topics due to the limited subject matter background. The importance attributed to subject matter knowledge is supported in the literature (e.g., Cantrell, et al., 2003) and is also at odds with other science teaching self-efficacy beliefs studies (e.g., Enochs, et al., 1995).

Prior employment and age are rarely discussed in the science teaching self-efficacy research. This study reports that age may be influential when it comes to science teaching self-efficacy beliefs. Stephanie and Willa were older than there cohort and attributed their science teaching confidence to their age. They reported that the evidence of past life and prior employment experiences had increased their awareness of their strengths and capabilities and also positively influenced their confidence to enter a new classroom and be the teacher of record.

Stephanie's belief that social/verbal support positively influenced her STEBI scores reflects similar findings in the research literature (e.g., Haney, et al., 2002; Ramey-Gassert, et al., 1996). Willa decided to return as a beginning teacher to the school where she had successfully student taught. Willa's STEBI scores also show that her science teaching self-efficacy scores increased during her student teaching and into her first year as a beginning teacher. For both of these teaching time periods, she reported limited social support from her science teacher colleagues. Her limited support and increasing science teaching self-efficacy belief scores contradict the published research findings concerning the positive influence of social/verbal support and STEBI scores.

This study sought to contribute to the body of science teaching self-efficacy beliefs research. This was done through the utilization an open ended, yet focused interview style to investigate the meaning participants gave to the mark they made on the Likert scale in responding to items about science teaching self-efficacy. These statements were coded to the STEBI items and a 94% interrater reliability was achieved. It is noted that the reliability of those statements was dependent on the accurate recollection of the participants. Although the audit trail for this study was extensive, the patterns and themes for each participant that emerged from this study were the result of the researcher's interpretations. In analyzing the collected statements, the STEBI items were validated 86% of the time. Total construct validation of the STEBI was not achieved due to participants' word substitution and varied interpretations of the STEBI items. Although this study potentially adds clarity to previous validation studies by investigating construct validity in a different manner and at another level, it also potentially calls into question prior studies using the STEBI instrument.

Areas for Further Research

These findings are particular to these two participants and not therefore generalizable to their cohort or to any other population. However, because the similar trends were seen in two independent individuals, these research areas discussed below may warrant further exploration.

Studies involving younger preservice teachers with limited life and employment experience might help confirm the existence of relationships between age and prior employment experiences and science teaching self-efficacy beliefs. Studies that investigate males' teaching self-efficacy beliefs would extend these findings. Studies investigating baccalaureate preservice elementary teachers might help to eliminate the division that is currently seen in the science teaching self-efficacy beliefs literature concerning subject matter knowledge. This study investigated a sample of high school teachers. With the predominance of elementary teacher samples in the science teaching self-efficacy research, this study's findings may represent a positive step forward in the field. More high school science teacher studies would provide the opportunity to confirm this new territory.

The open ended, yet focused, interview investigated the meaning the participants gave to the mark they made on the Likert scale in responding to items about science teaching self-efficacy. Their responses were retrospective, however, in regards to their preservice year STEBI scores. This time lag may account for the limited responses related to vicarious experiences and physiological and emotional arousal. A study using interviews after each administration of the STEBI might provide data that would strengthen this study's findings and add to the research base.

Researchers could increase validation of the constructs contained in the STEBI by modifying the delivery and form of the survey. If the STEBI was created into an electronic form and sent through email, participants could take it within a certain window of opportunity and at a time that was convenient to their schedule and energy level. The threats of construct underrepresentation and construct-irrelevance might be lessened by having the participants check a box to indicate the type of science class or grade level they are considering when they answer the STEBI questions. Windows beneath each item could also be incorporated into the form for participants to supply additional information regarding what they thought contributed to or influenced their STEBI score. With these proposed delivery and response modifications to the STEBI, its construct validation may be improved.

Post Script

Human performance is dependent on not only the individual's beliefs but also on the environment and the behavior itself. Bandura (1986) called this a transactional social cognitive view of self and society in which the self is socially constituted and individuals are partial contributors to what they become and do. Human performance (agency) is composed of three determinants: 1) personal factors: internal factors such as personality characteristics, cognitive processes and teaching self-efficacy beliefs, 2) behavior (the nature, frequency, and intensity of the action) and 3) environmental: external factors (stimuli from social or physical environment).

High teaching self-efficacy beliefs are positively correlated with participants' choosing to teach science and persistence in the teaching profession (Friedman, 2003; Mulholland & Wallace, 2001; Ramey-Gassert et al., 1996; Ware & Kitsantas, 2007). It is recognized that Stephanie and Willa are only two individuals and as such this study's findings and this post script are limited to those two individuals. This post script is presented as a tentative counterpoint to those findings.

Stephanie's Story

Stephanie never knew her STEBI total scores or that she was in the high level category. When asked where she would place herself in terms of her science teaching self-efficacy beliefs she responded:

> (interview lines 2247- 2266)
> "I think that overall, looking back, I think I was probably in the very beginning, high. So I felt going into it that I could be a good teacher. Teaching was where I really felt my heart being pulled toward. For me, it was very much this is what I want to do. The thing of it is, that for me, even though I answered 5 that isn't the end of my journey. For me, because in my mind it goes 6, 7, 8, 9, 10, it keeps going. So I am always going to be striving…"

Stephanie continues to teach high school science. Shortly after the end of this study, she accepted a contract to teach high school biology and integrated science, fulltime in the same state in which she completed her MAT program. Stephanie's teaching story continues with her last email:

> (email communication lines E 130-135)
> "I got to see my classrooms today and pick my office. I am going to put my fish tank in… and some of my cooler plants. I took in all my curriculum material and started to unpack. It is feeling like my place now. And I have keys! I am official! I am so excited."

Willa's Story

Willa's professional teaching story started out similarly to Stephanie's; she also returned to teach at the high school where she student taught. Willa believed this choice would work well with her son's schedule and keep her within the community. At the time of this study's first interview, Willa had signed her contract for the next teaching year and had been accepted to two professional development summer programs at MIT and Cornell but then had decided to resign from her high school position at the end of her beginning year of teaching.

She followed through with that decision and returned to work force as an engineer for a start-up company. She plans to continue working with the Invent club at the school where she had been teaching and also volunteer for the science club at her son's school. She also plans to do substituting: "to carry me through while the (*engineering*) company grows" (interview line 594).

Willa ended with increased science teaching self-efficacy beliefs, to the point that she had moved from the middle self-efficacy group to the high self-efficacy group. Even so, Willa's decision to leave high school science teaching is not unusual in the teaching profession. Almost half of the beginning teachers leave teaching in the first five years, with science and mathematics teachers the most likely to leave in comparison to other teachers (Liu, 2007). The reason often given for leaving science and mathematics teaching is the fact of higher remuneration in industry and business. This was not the case for Willa.

Willa had heard: “a lot of ‘the kids are so great’ and ‘having your own classroom is so different (better) and so much more fun’ ” (letter communication lines 45 and 46). Based on her beginning year’s experience, Willa found the majority of her students to be: “immature, (*needed to be*) clean(*ed*)-up after every day, (*unable to*) isolate a variable, arrogant and not empathetic” (interview lines 469, 622, 392; letter communication line 85). In regards to the being a classroom teacher: “the repetition (*of teaching four sections of the same class*) kind of drove me crazy. I don’t like being in the classroom… that long. I feel really constrained. I am used to a job where I am moving around. (*I also like to*) go on a vacation in February” (interview lines 650-652, 679). From the students and parents, she did not feel that she was: “respect(ed) for my position or what I am doing” (interview line 1756). Having lived in the same community and done her student teaching at the school, Willa was familiar and uncomfortable with working for a union:

> (interview lines 515-526)
> “I think it is not this school. I think every school has that. I’ve never worked for a union in my life. I think it creates a big gap between administration and teaching, teachers. I think they are treated differently. The administration looks like they have to… in a way control the mass of teachers. What are the teachers doing? It is like them and us. The teachers look at it that way, too. Like: ‘Oh, they are going to try and screw us’ that type of thing.”

Willa did not feel that the above reasons for her leaving had: “to do with working specifically at [the school]” and she stated that she left her surprised principal and position on “good terms” (letter communication line 22, interview line 1313). She had: “expected more from students and really (*did*) not want to have to come up with a new dog and pony show every day” (letter communication lines 84-85). She wished she could: “be a better person than I am. Sometimes I just can’t stand the kids, so I would like to be able to do that better, but I’m not sure if my personality is cut out for it” (interview lines 1726-1728). However, she was also 45 years old and:

> (letter communication lines 24, 25, 50 and 51)
> "quicker now at realizing when I have made a mistake and less tolerant of what I do not want to do. I am not a martyr and will not spend my life in a career that I do not feel cut out for, and I do not feel 'right' teaching."

Willa's retained her high science teaching self-efficacy beliefs. This statement is substantiated throughout the data collected after she resigned by the numerous references to her belief that she would have continued to improve if she had returned to teaching. Her decision to leave high school science teaching had: "more to do with the general teaching profession and my 'fit' in it… versus what I believe that I am capable of accomplishing" (letter communication lines 24-25). She recognized her entry into the teaching profession as a mistake. Willa's training was as a failure analysis engineer. In choosing to leave the teaching profession, perhaps Willa had done her job to the end.

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Chapter 4: General Conclusions

This dissertation consists of two articles to be submitted for publication. The first, a literature review, makes visible common influences on science teaching self-efficacy beliefs and also points to potentially invisible validation concerns regarding the instrument used. The second investigates the participants' invisible science teaching self-efficacy beliefs and, through the use of a more focused interview, makes those beliefs visible.

Science teaching self-efficacy beliefs are science teachers' perceptions of their abilities to teach science effectively. The construct "teaching self-efficacy" originated in social cognitive theory (Bandura, 1977). The first article reviews the mixed results from teaching self-efficacy research in science contexts. The review focuses upon factors that facilitate or inhibit the development of self-efficacy beliefs among science teachers across stages of their careers. Although many studies of science teaching self-efficacy beliefs have utilized the Science Teaching Efficacy Belief Instrument - STEBI (Enochs & Riggs, 1990; Riggs & Enochs, 1990), this review also includes non-STEBI studies in order to represent diverse lines of research methodology.

Based on the studies reviewed, experiencing science as a student seems to be influential on science teaching self-efficacy beliefs levels and on choosing to become a teacher of science. High school science was also influential on science teaching self-efficacy beliefs, but with mixed results. As they enter college, elementary preservice teachers science content knowledge was reported to be low or in need of development.

Although the majority of the studies ended on a positive note (i.e. self-efficacy levels improved or rebounded), the path was not linear and in some of the longitudinal studies it was even cyclical. This was particularly evident after student teaching, where preservice teachers usually experienced a decrease in efficacy, perhaps due to over-inflated personal or underestimated context complexity beliefs. Without exception, teacher education programs that incorporate many and early field experiences were generally and significantly related to increases in science teaching self-efficacy. Researchers advocated gradual field experiences would aid in the development of the preservice teacher's efficacy beliefs. When provided activity based opportunities to interact with science content in science methods classes, the preservice teachers' science content knowledge and teaching efficacy levels.

Another theme in the research presented here was the potentially positive influence a supportive context during preservice field experiences and jobsite might have. Only two studies found science teachers' efficacy to be directly connected with the level of preparation they felt going into the science classroom. They also both published significant correlations between high school science teacher's science teaching self efficacy and the level or track of science class they taught.

The majority of educational research dealing with teaching self-efficacy beliefs were short term studies that relied on a single administration of an instrument and the collection of antecedent/demographic and/or interview data. Although the literature review found mixed antecedent results it also pointed to the power of antecedents. There is a need for researchers and teacher education programs to investigate these antecedent influences and to provide teachers with opportunities and experiences that aid in the development of higher science teaching self-efficacy.

The predominance of short term duration studies is a problem when it comes to investigating how science teaching self-efficacy beliefs develop and are influenced along a teacher's career path. A few of the newer studies framed their analyses on Bandura's four sources of efficacy: 1) mastery experiences – an individual's past successes and failures; 2) vicarious experience – skill in question is modeled by someone considered competent by and comparable to the individual; 3) verbal/social persuasion - encouragement received from a knowledgeable source and 4) physiological and affective states in their analyses. The efficacy source identification guide by Brand and Wilkins (2007) may provide a more valid way for researchers to investigate the efficacy sources that may be provided by their methods class or professional development workshop. The use of multiple researchers to code to these sources would add to reliability of a study and also add to the body of research.

In the studies reviewed, the interviewers did not investigate the participants' thinking and reasoning concerning the mark on the survey items. In the analysis phases of these studies, the researchers made the connections of the life/educational experiences to the survey answers. With longer studies using methodologies involving the sources of efficacy and focused on reasons for survey answers, findings may better guide creation of teacher education programs, job contexts and professional development opportunities that enhance a teacher's science teaching self-efficacy beliefs. Armed with how to help teachers develop their teaching efficacy beliefs, teacher educators may be able to slow down the loss of science teachers to business and industry. If a greater number of efficacious science teachers remain in their classrooms and persevere with being good science teachers, students might likely enjoy and learn science more easily and their achievement scores might reflect that science knowledge.

However, the above statements are hypothetical. The design and methodological concerns presented in this literature review are shared by others in teacher efficacy research (Henson, 2002; Tschannen-Moran et al., 1998). The idea of teaching self-efficacy is a maturing construct, both in terms of its meaning and measure. Teacher efficacy research, grounded largely within social cognitive theory (Bandura, 1986), has been set within the conceptual and methodological approaches of psychology. Such a focus has resulted in research dominated by quantitative methodologies exploring relations among antecedents and consequences of science teaching efficacy beliefs. Although such research has been successful in establishing the power of teaching efficacy beliefs there should also be recognition of the limits of such research and a consideration of other perspectives and methodologies (Labone, 2004).

In focusing on how efficacy information is sourced and processed by the participants, perhaps Henson's aspiration is possible:

> "To fully understand the relationships the sources of efficacy information, the meaning teachers attach to this information, and any ultimate change in their efficacy beliefs, in-depth study of teachers is necessary" (Henson, 2002, p. 147).

The second article documents a study that responded to the above literature review findings. This study utilized multiple STEBI administrations during the preservice and beginning year of teaching for two science teachers. Rather than general questions, these participants were asked item specific, yet open-ended, questions to determine what events or experiences the participants felt influenced their survey answers. This methodological approach was chosen to add clarity to the STEBI scores and to add another layer in the ongoing process of instrument validation.

Both participants successfully completed the MAT program, were granted licensure and secured jobs as beginning teacher at the high schools where they had student taught. In comparing their beliefs at the beginning of their MAT program and at the end of their first year as beginning teachers, both participants indicated that they had increased their science teaching self-efficacy beliefs as their survey totals below show. Not only were greater science teaching self-efficacy gains seen in both data sets, but one participant’s scores had moved her from the medium to the high STEBI group at the end of her beginning year of teaching.

The above findings contradict the majority of results presented in the science teaching self-efficacy research. To explore the possible reasons for this study’s contrasting findings, the antecedent survey and participant attribute data (from their interviews, emails and letters) are discussed in the following paragraphs.

Both participants attributed the majority of their increase and levels in science teaching self-efficacy beliefs to their teaching experiences. The second most commonly mentioned influence on the participants’ science teaching self-efficacy scores was the subject matter knowledge gained from their college coursework and their previous jobs. Although age has been included in previous science teaching self-efficacy research, it has been mainly treated as a descriptive piece of data describing the sample. Both participants were older than average students and believed they knew themselves and their strengths and had left previous employment experiences to become teachers. In comparing themselves to their younger cohort members, both participants attributed their age as a positive factor in their enrolling in the MAT and to their wanting to be teachers. One last source of mastery experiences was found in the participants' prior employment.

Vicarious experiences involve a skill in question being modeled by someone considered competent by and comparable to the individual. This source differed in terms of occurrence for the participants: one never mentioned it at all; one mentioned it positively, once. Both participants mentioned aspects of verbal/social support in response to questions concerning their STEBI scores. One participant strongly attributed increases in her responses to the social support she received from people who gave her feedback and encouragement: her family, mentors, jobsite faculty and her students. The other participant also mentioned social support, but in her case it was the lack of it.

The source of self-efficacy originating from physiological and emotional arousal that is then manifested by the body is the least cited in the literature (e.g. Bleicher, 2006) and in this study. Bandura states that this source of efficacy is created by individuals: "in coping with threatening situations" (Bandura, 1977, p. 198). Individuals conjure up fear-provoking thoughts about their ineptitude and rouse themselves to: "elevated levels of anxiety that far exceed the fear experienced during the actual threatening situation" (p. 199). Neither participant ever exhibited in their words or in their body language fear and anxiety. Both participants both recognized they had areas in their teaching that might need improvement. Both of them, however, recognized those areas without obvious fear and proceeded to view a potentially threatening experience as an opportunity to improve themselves as teachers.

This study was also intended to be a validation study of the STEBI constructs. This study used questions that focused specifically on the participant's score levels and score changes for each STEBI item. Through the use of direct probes, this study sought to add clarity to the STEBI instrument by utilizing another, more specific, level of construct validation. In general terms, the scores of the thirteen STEBI items were validated by the participants' statements. To limit the possibility of leading the witness, specific and open ended questions were asked for each STEBI item. Assessment data (e.g., the STEBI scores presented in this study) are more or less valid for some very specific interpretation at a given point in time and only for some well defined population (Downing, 2003). It was never the intention of this study to be generalizable beyond the two participants. However, in using two participants rather than one, trends and patterns were found in their independent responses which can be used as further evidence that the STEBI scores were validated by the participants' statements.

In analyzing the collected statements, the STEBI items were validated 86% of the time. Total construct validation of the STEBI was not achieved due to participants' word substitution and varied interpretations of the STEBI items. Response process is defined as: "evidence of data integrity such that all sources of error associated with the test administration are controlled or eliminated to the maximum extent possible" (Downing, 2003, p. 834). The remaining paragraphs of this section, although not attempting to discuss *all* sources of error, does attempt to present areas in which the construct validity of the STEBI was threatened. Occurring once, the first threat considered is construct underrepresentation: the assessment is too narrow and fails to include important dimensions or facets of the construct (Messick, 1995). Occurring four times, the second threat to the construct validity was seen in construct-irrelevance variance: the assessment is too broad; other distinct constructs affect the responses (Messick, 1995). Although this study potentially adds clarity to previous validation studies by investigating construct validity in a different manner and at another level, it also potentially calls into question prior studies using the STEBI instrument.

Studies involving younger preservice teachers with limited life and employment experience might help confirm the existence of relationships between age and prior employment experiences and science teaching self-efficacy beliefs. Studies that investigate males' teaching self-efficacy beliefs would extend these findings. Studies investigating baccalaureate preservice elementary teachers might help to eliminate the division that is currently seen in the science teaching self-efficacy beliefs literature concerning subject matter knowledge. This study investigated a sample of high school teachers. With the predominance of elementary teacher samples in the science teaching self-efficacy research, this study's findings may represent a positive step forward in the field. More high school science teacher studies would provide the opportunity to confirm this new territory.

The open ended, yet focused, interview investigated the meaning the participants gave to the mark they made on the Likert scale in responding to items about science teaching self-efficacy. Their responses were retrospective, however, in regards to their preservice year STEBI scores. This time lag may account for the limited responses related to vicarious experiences and physiological and emotional arousal. A study using interviews after each administration of the STEBI might provide data that would strengthen this study's findings and add to the research base.

Researchers could increase validation of the constructs contained in the STEBI by modifying the delivery and form of the survey. If the STEBI was created into an electronic form and sent through email, participants could take it within a certain window of opportunity and at a time that was convenient to their schedule and energy level. The threats of construct underrepresentation and construct-irrelevance might be lessened by having the participants check a box to indicate the type of science class or grade level they are considering when they answer the STEBI questions. Windows beneath each item could also be incorporated into the form for participants to supply additional information regarding what they thought contributed to or influenced their STEBI score. With these proposed delivery and response modifications to the STEBI, its construct validation may be improved.

For this dissertation, the first article – the literature review revealed potential areas for exploration: 1) need for more longitudinal studies, 2) usage of survey instruments multiple times, and 3) focusing the interview questions to probe the meaning participants' attribute to their survey response answers. Responding to that literature review's findings, a study was designed to investigated those three areas. In so doing, new areas of the research base were explored: 1) social support may not be a necessary source for positively influencing science teaching self-efficacy beliefs, 2) age and prior employment seem to be influential on science teaching self-efficacy beliefs, 3) interview frequency might expand the current findings if it matched the timing and frequency of the STEBI administrations and 4) using a focused, yet open-ended interview style that probed the meaning participants' attribute to their survey response answers and was shown to validate the STEBI items 86% of the time.

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APPENDICES

Participant selection

The selection of two participants from the group of cohort members with complete data sets was based on the initial preservice survey score (STEBI B) and established by two different methods. The first method, the raw scores of the STEBI B was converted into standardized *z*-scores. The *z*-score indicates how many standard deviations a particular raw score lies above or below the group mean. With *z*-scores, the mean is fixed at zero. Thus in Willa's case a *z*-score of -0.41 indicated that she scored 0.41 standard deviations below the group mean. Stephanie's *z*-score was 0.89 and indicated that she scored 0.89 standard deviations above the group mean. The statistical distance between Willa and Stephanie was 1.30 standard deviations.

The second method was based on previous research (Ginns & Watters, 1999) and utilized established scores for grouping the cohort into high (STEBI scores > 50) and medium (STEBI scores between 40-50) levels. In looking at the participant selection chart below, none of the cohort qualified for a low group designation (STEBI scores < 40).

Trying to find more "extreme" participants in the high and medium groups (based on their *z*-scores) proved to not be possible. Participant A was on maternity leave and no longer teaching. Participant B was now teaching math. Participant C could not be found, and Participant L declined to participate in this study do to the busyness of her science teaching schedule. The two remaining participants, Stephanie (high group) and Willa (medium group) agreed to participate with this study and had successfully completed their first year as beginning science teachers.

Table 37. Participant Selection

Participant	STEBI B	z score based on STEBI B	efficacy level
A	43	-1.71	medium
B	44	-1.45	
C	46	-0.93	
Willa	48	-0.41	
D	48	-0.41	
F	51	0.37	high
G	51	0.37	
H	51	0.37	
I	52	0.63	
J	52	0.63	
Stephanie	53	0.89	
L	56	1.67	

Last 4 Digits of SSN __ __ __ __ Name (optional)____________________

STEBI FORM B (Preservice Teacher)

****

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

****

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 teaching.	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

(NB: The below STEBI A is a shortened form from the original. This is due to the intentional omission of items dealing with outcome expectancy. This action was felt to be reasonable due to the dissertation’s focus on science teaching self-efficacy beliefs, which is a separate and different construct.)

Last 4 Digits of SSN __ __ __ __

STEBI Form A (Inservice Teacher)

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

2.	I am continually finding better ways to teach science.	SA A UN D SD
3.	Even when I try very hard, I do not teach science as well as I do most subjects.	SA A UN D SD
5.	I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6.	I am not very effective in monitoring science experiments.	SA A UN D SD
8.	I generally teach science ineffectively.	SA A UN D SD
12.	I understand science concepts well enough to be effective in teaching elementary science.	SA A UN D SD
17.	I find it difficult to explain to students why science experiments work.	SA A UN D SD
18.	I am typically able to answer students' science questions.	SA A UN D SD
19.	I wonder if I have the necessary skills to teach	SA A UN D SD

science.

20. Given a choice, I would 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 am usually at a loss as to how to help the student understand it better. SA A UN D SD

22. When teaching science, I 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

Table 38. STEBI Reliability Information

Source Science Teaching Efficacy Beliefs: Elementary Inservice (Riggs & Enochs, 1990)	STEBI-A	SE	0.92
Science Teaching Efficacy Beliefs: Elementary Preservice (Enochs & Riggs, 1990)	STEBI-B	SE	0.90

Antecedent Survey (Cantrell et al., 2003)

DEMOGRAPHIC AND BACKGROUND SURVEY

1. Where are you currently teaching?

2. What is your current class load in the areas of mathematics and science?

3. The major portion of my time in science instruction is be spent in:
   a. Textbook-based presentation only
   b. More textbook-based presentation than anything else
   c. An equal amount of textbook-based presentation and activity-based instruction
   d. More activity-based instruction than textbook-based presentation
   e. Activity-based instruction only

4. *______ About how many total hours did you spend teaching mathematics during your teacher preparation field experiences?*

5. *______ About how many total hours did you spend teaching science during your teacher preparation field experiences?*

6. *______ Did you participate in extra-curricular science activities such as science fair or science Olympiad in high school? (yes/no)*

7. *Please check the high school mathematics and science courses you completed and circle either full year or one semester according to the amount of high school credit your received:*
   ___Algebra - - - - - - - - - - - - -Full year or 1 semester (circle one)
   ___Geometry- - - - - - - - - - - -Full year or 1 semester (circle one)
   ___Trigonometry- - - - - -- - - -Full year or 1 semester (circle one)
   ___Algebra II- - - - - - - - - - - -Full year or 1 semester (circle one)
   ___PreCalculus- - - - - - - - - -Full year or 1 semester (circle one)
   ___Calculus- - - - - - - - - - - - -Full year or 1 semester (circle one)
   ___Other:___________ - -- - -Full year or 1 semester (circle one)
   ___Biology- - - - - - - - - - - - - Full year or 1 semester (circle one)
   ___Chemistry- - - - - - - - - - - Full year or 1 semester (circle one)
   ___Physics- - - - - - - - - - - - - Full year or 1 semester (circle one)
   ___Earth Science- - - - - - - - - Full year or 1 semester (circle one)
   ___Anatomy/Physiology- - - - Full year or 1 semester (circle one)
   ___Other:___________ - -- - -Full year or 1 semester (circle one)

8. Please list the college mathematics and science courses you have taken (NOT COUNTING MATH OR SCIENCE EDUCATION)

______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

9. Please list and job or professional experience you have had that involved the usage of mathematics or science.

10. Gender: ___F ___M

Interview Procedures

The researcher reviewed the scores from the STEBI survey set generated during the year in the MAT program. This data was augmented by an antecedent survey and additional STEBI survey emailed to the participant prior to the 1st meeting. Each participant agreed to two interviews, the first focused on the participant's antecedent information and general discussion about the MAT program, teaching and the first teaching year. The researcher deliberately chose this focus for the first interviews to increase her knowledge regarding the participant. The researcher was also aware of the possibility that her background (as a university supervisor at another teacher education program and as a ms science and math teacher) might influence her interpretation of the participant data. The first interview was therefore conducted to help increase the researcher's knowledge regarding the participant's mindset, background, and school contexts. Once this mutually understood content was discussed, subsequent interview questions focused solely on the participant's STEBI answers and to what the participant attributed to the levels and changes in their survey scores.

The questions for both interviews were probing and confirmatory in nature. For example, in the first interview the antecedent information was often used as the initial probing prompt:

(interview lines 105-106)
Researcher: How did you end up at Murray Hill High School?…
How did you get that far south?

An example of a first interview confirming prompt regarding the participant's belief about knowing the steps necessary to teach science concepts effectively:

(interview lines 850-859)
Participant: I don't know everything yet. I don't know all the steps but I'll learn them. Now that I have been teaching on my own, I realize that, you know, I don't know if there is necessarily any set steps to teaching science, and if there are, I haven't come across them.

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Researcher: You are knocking it (*this STEBI item's score*) down not because your belief is lesser, but you are taking issue with the (*the word*) step?

Participant: Right, because I think there probably are lots of different ways to teach science and they may not necessarily all include the same steps.

In the second interview, the STEBI items became the focus of the discussion. Participants were shown their STEBI scores (the 5 generated during their MAT and the newly completed STEBI from the end of their first year of teaching). The researcher verbally reviewed the scores for the item to be discussed while physically pointing to the item and making gestures to mimic the score pattern. This interview was retrospective in nature with the participant's statements originating, in some cases, from events that occurred almost two years ago. Working on the assumption that the participants would not be able to recall their STEBI responses from almost two years ago, the researcher showed their scores to them in hopes of refreshing their memories and providing a focus for the interview.

Similar to the first interview, the second interviews questions were probing in nature. The example below occurred during a discussion of the participant's confidence in monitoring science experiments:

(interview lines 1443-1447)
Participant: (*Participant mimicking a student*) 'Miss Stephanie, did you know wax paper will light up like a big. . .' I am like, that's fabulous.
Researcher: I didn't know that (*wax paper was highly flammable*). Tell me a little bit more on that one.

Or as in the case of trying to determine the timing of an event, confirmatory question:
(interview lines 2039-2040)
Researcher: That was during student teaching?

The second interview also provided an opportunity to elucidate information that had come up in the first interview:

(interview lines 1211-1219)
Researcher: Looking at the dip, we are talking about, finding those better ways, bigger and better, why was it a little bit

lower in the first practicum before you hit student teaching? Any ideas?

Participant: I think because I was wondering if I would be able to find those better ways. I knew that I wanted to, but maybe it would be a harder process than I thought to find those better ways of teaching science. I kind of question, not my desire to do it, but maybe my ability to find those better ways. I think after I did my student teaching and was actually looking at activities and revising them as I needed, I felt like, okay, yeah, I think I can do this as I get better and better.

Coding Procedures

The interview data were transcribed. Each participant's interview transcript was coded to the individual 12 STEBI self-efficacy items. A database was created in which each worksheet was dedicated to one STEBI item and contained interview data specifically related to this item. Relative interview sections could be the participant's attributions as to her score levels or changes in the scores and also interview sections that the researcher felt provided insight or antecedent information related to those attributions. To help with the reliability of the coding, another researcher also coded a subset of the data. This researcher had recently received her doctorate in science education, had worked with a known efficacy researcher and had utilized the STEBI and Bandura's theoretical framework in her thesis. All coding was done independently and separately. Initial coding was by item – interview lines coded to individual STEBI items for each participant. The files containing these coding were exchanged, the primary researcher compiled the combined codings, noted agreed sections and provided rationale for the coded sections not agreed upon. The primary researcher then calculated this first round of interrater reliability for the coded interview sections for the item. This compiled file was then sent to the second researcher, who reviewed the first researcher's rationales, responded with either agreement or continued commitment to her initial coding. With the second round of discussions completed, the file was sent back and the first researcher then calculated the interrater reliability for the coded interview sections for the item. Based on Miles and Huberman (2005), reliability was the result of dividing the number of agreements by the total number of agreements and disagreement. It was the intention of the researchers to seek an internal consistency of their coding: "… up in the 90% range" (p. 64). Below is a table of the interrater reliability rates.

Table 39. Participant Item Coding

	PARTICPANT ITEM CODING	
STEBI item	Stephanie	Willa
2	100%	81%
3	100%	95%
5	89%	100%
6	100%	100%
8	97%	97%
12	100%	96%
17	100%	92%
18	100%	100%
19	92%	86%
20	100%	100%
21	78%	93%
22	100%	85%
23	81%	100%
AVERAGE	95%	94%

Table 40. Clustering of STEBI items into analysis groups

CLASSROOM TEACHING PRACTICES	
2	I will continually find better ways to teach science.
3R	Even if I try very hard, I will not teach science as well as I will most subjects.
8R	I will generally teach science ineffectively.
19 R	I wonder if I will have the necessary skills to teach science.
20 R	Given a choice, I will not invite the principal to evaluate my science teaching.
21 R	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.
INTERACTIONS WITH STUDENTS	
18	I will typically be able to answer students' science questions.
22	When teaching science, I will usually welcome student questions.
23 R	I do not know what to do to turn students on to science.
SCIENCE CONTENT KNOWLEDGE	
5	I know the steps necessary to teach science concepts effectively.
12	I understand science concepts well enough to be effective in teaching elementary science.
SCIENCE EXPERIMENTS	
6R	I will not be very effective in monitoring science experiments.
17 R	I will find it difficult to explain to students why science experiments work.

Table 41. Time ordered meta matrix for Item 20

20	Given a choice, I will not invite the principal to evaluate my science teaching.				
	survey administration				
PARTICPANT	**I**	**II**	**III**	**IV**	**V**	**BT**
STEPHANIE	Before, because I didn't have that much experience with principals in the school setting yet and know kind of what they might be expecting from me and what I can expect from them LINES 939-940	...it is like, okay, well, am I going to have a good relationship with my principal? Am I going to feel like they are coming in to observe me because they really want to see my teaching style or because they want to come in and judge me? LINES 1991-1993 I think it really becomes a factor of do I feel comfortable with my principal. Do I feel like they really are interested in me as a teacher and they support me? If they do, then yeah, I'm all for having them come in and watch me teach. If I don't have a good relationship with my principal, I may be a little bit more . . . yeah, I would want to make sure it was a really good day that they came and watched. LINES 1993-1996				I think just as I have become now I am more comfortable. Also as a teacher I am more comfortable that I am not so worried about screwing up in front of the principal if he does come into my class. LINES 939-942