EFFICACY BELIEFS OF TEXAS COMPOSITE SCIENCE AND SUBJECT-SPECIFIC

CERTIFIED BIOLOGY TEACHERS

A Dissertation Presented to the
Faculty of the College of Education
University of Houston

In Partial Fulfilment
of the Requirements for the Degree

Doctor of Education

by

Philomena Ngozi Agu

August 2018

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Acknowledgment

I would like to express my sincere gratitude to my dissertation committee members, Dr. John Ramsey, Chairperson, Dr. Weihua Fan, Dr. Laveria Hutchison, Dr. Cameron White, and Dr. Sissy Wong for your advice, expertise, wisdom, and knowledge. The successful completion of this dissertation would not have been possible if not for the critical feedback you all have given me. I am grateful. I extend to Dr. Ramsey (my advisor) my heartfelt gratitude. He has been available every step of the way, guiding and encouraging me. Thank you, Dr. Ramsey. A special thanks to Dr. Catherine Horn for helping to modify and edit the instrument. This project began in your survey methods class.

My special gratitude belongs to my husband, Anthony, and my two sons, Oluchukwu and Gabriel, who have patiently allowed me to pursue this degree and listened to my frustrations along the way. I am grateful to my parents. Papa, although you physically departed from this world when I was very young, your spirit and legacy always remained and nurtured me. Mama, I am blessed to have you as my mother. I thank you for instilling within me the love of learning. Thank you for your encouragement, love, dedication, and prayers. To my aunt, Reverend Sister Vero, I thank you immensely for constantly praying for me and encouraging me. Finally, I am very grateful to my siblings, Vero, Uzo, Ify, Melvy, Oly, and Chidi who provided moral and spiritual support to me. I am incredibly grateful to you all. I thank God for inspiring me and for guiding me to produce and complete this project.

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Abstract

Background: Research has shown that certification and an undergraduate major in a teaching subject are consistent positive-significant predictors of teacher effectiveness and the lack of at least a minor in an assigned subject as a a consistent and negative indicator of student success. Texas secondary science teachers have either subject-specific certifications or composite science certifications. Studies revealed that a majority of prospective high school science teachers prefer to obtain certification in composite science. Certification in composite science qualifies a candidate to teach most academic science courses. However, composite teachers may be assigned to teach subjects for which they have little academic preparation. Thus, their sense of efficacy may be impacted. Several studies explored the efficacy of teachers certified in a single science subject. Minimal work examined the effectiveness of composite teachers. Studies have used scores on Personal Efficacy and Outcome Expectancy subscales in Science Teacher Efficacy Belief Instrument (STEBI) to measure teacher effectiveness. Few scales exist specifically for high school science subject teachers. Hence, STEBI was adapted for this study. **Purpose:** This study aims to explore the validity and reliability of a modified STEBI and to compare Personal Efficacy (PE) and Outcome Expectancy (OE) of composite-certified teachers with the subject-specific teachers. **Methods:** Using the adapted STEBI, PE and OE were assessed for 562 biology teachers. The validity of the instrument was examined using Principal Component Analysis (PCA) and Confirmatory Factor Analysis (CFA), and the reliability established with Cronbach's alpha. A hierarchical multiple regression analysis was used to compare PE and OE of composite teachers and subject-specific teachers controlling for undergraduate major and teaching experience. **Results:** The PCA supported the validity of the instrument. The subscales were reliable; alpha was .81 and .81. Certification did not predict PE or OE. The teaching experience significantly predicted personal efficacy. An undergraduate major in a teaching subject, biological science, predicted a higher level of personal efficacy and outcome expectancy than did an undergraduate major in a different field. The majority of composite teachers teach biology. **Conclusion:** STEBI could be adapted to study efficacy beliefs of high school subject teachers. However, subject-specific certification and composite certification did not yield significant differences.

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Chapter I

Introduction

Before the late 1990s, the state of Texas required prospective high school science teachers to take relevant college coursework to become certified in a teaching subject. Currently, the requirement is certification by examination. The state offers tests in subject-specific science fields in addition to tests in composite science (broad science, general science, and science 7-12). This study considers biology and life science as subject-specific certification fields.

A candidate seeking certification in a science field is often not required to possess an undergraduate degree major in a teaching subject. The Texas Examination of Educator Standards (TExES) tests are often the primary means of verifying content knowledge of a candidate. Currently, composite science and life science tests are available to biology teachers because the state discontinued certification in biology. The TExES test in life science and composite science contains questions in four similar life science domains including cell structure and processes; heredity and evolution of life; diversity of life; and interdependence of life and environmental systems (TExES Tests at a Glance, TEA-SBEC, 2017). However, the concentration of questions varies. In TExES composite science (science 7-12), the sum of questions in the life science domains is only 30 percent of 140 questions. In contrast, 75 percent of 100 questions in TExES life science exams are in the domains of life science (TExES Tests at a Glance, TEA-SBEC, 2017). The trend is similar in most secondary science content tests. The concentration of questions varies from very low in composite science to very high in subject-specific fields.

A candidate certified by each test, composite science or life science is qualified to teach biology and other life science courses. The minimum score to pass each science exam is the same, and the test format appears similar, mostly multiple-choice questions. However, candidates who took the life science test seemed to demonstrate more knowledge of life science contents by answering more questions. Thus, there may be an impact on teaching effectiveness of the composite teachers. Yearly, a high majority of science teacher candidates obtain certification in composite science compared to life science (Ramsay, 2013, 2015, 2016). Composite science (science 7-12) “assess whether a beginning teacher has the requisite knowledge and skills to teach a subject of interest” (TExES Tests at a Glance, TEA, 2017, science 7-12, p. 2). However, empirical evidence supported that teacher effectiveness and teaching experience was not always linear (Darling-Hammond, 2000). Thus, a novice teacher may or may not develop more knowledge of biology content with experience.

The No Child Left Behind (NCLB) law requires all core academic teachers to be highly qualified. The NCLB act defined a highly qualified teacher with three criteria: (a) holds a bachelor’s degree, (b) obtains certification, and (c) demonstrates subject-matter competency. According to Darling-Hammond (2000), teacher certification status measures teachers' knowledge of subject matter, teaching, and learning. A certified teacher, therefore, is expected to have high content knowledge, to use effective instructional strategies, and to have the capability to advance students’ learning gains. The effectiveness of composite teachers and subject-specific teachers (life science and biology) is assessed indirectly in this study by investigating their teaching efficacy beliefs.

When Riggs and Enochs (1990) observed that elementary teachers lacked effectiveness in teaching and learning science, Riggs and Enochs proposed an investigation of the teachers' efficacy beliefs as evidence of characterizing the teachers’ behaviors. Similarly, if differences in teaching effectiveness exist among biology teachers certified in composite science and subject-specific science fields, then an assessment of their teaching efficacy beliefs could reveal those differences. Studies showed that teacher scores on teaching efficacy belief instruments were used to measure differences in the teachers’ use of effective instructional pedagogy (Ashton & Webb, 1986; Czerniak, 1989; Czerniak & Schriver, 1994); science content knowledge (Bergman & Morphew, 2015; Menon & Sadler, 2016), and the ability to increase students' academic achievement (Angel & Moseley, 2009; Hoy & Woolfolk, 1990; Lumpe, Czerniak, Haney, & Beltyukova, 2012). This study did not directly measure instructional behavior or the ability of the teachers to influence students' learning positively. However, this study assumed that the composite science or subject-specific certified teachers with high scores on the teaching efficacy belief instrument would have the capacity to provide effective instruction and consequently to increase student academic achievement in biology.

Riggs and Enochs (1990) deviated from using a general teacher efficacy belief instrument in their study because of the "dependency of the construct upon a specific teaching situation" (Riggs & Enochs, 1990, p. 7) and thus developed a Science Teaching Efficacy Belief Instrument for measuring efficacy beliefs of elementary science teachers. Many empirical studies adapted the Science Teaching Efficacy Belief Instrument (STEBI) for use in both elementary and middle grades. However, a minimum of such science specific scales exist for high school science teachers. Consequently, there is a need and an opportunity to develop or adapt an existing instrument. Moreover, most studies examined subject-specific certification. Minimal work was done to assess the efficacy beliefs of teachers who teach the same academic high school science subject but obtained certification by tests with varying degrees of content per a reference subject. Consequently, there is a gap that this study was designed to address.

Teaching experience is a control variable in this study because Darling-Hammond (2000) suggested that teacher experience could be a confounding variable in a certification study. The participants belonged to one of the three experience groups, novice (0 to 5 years), intermediate (6 to 10 years), or veteran (11 years and up). This grouping is slightly consistent with groups found in Childs and McNicholl (2007). Childs and McNicholl compared the effectiveness of novice teachers who taught science subjects within the area of specialty and outside their field of specialization. Childs and McNicholl grouped teachers with 0 to 5 years of experience as novice and teachers with more than five years' experience as the veteran. Within the experience group, four teachers had more than ten years teaching experience. In this study, the composite science teachers could be instructors in the out-of-field subject (outside subject of expertise) and in-field subject (within the subject of specialization). Thus, the idea of grouping the teachers came from Childs and McNicholl (2007).

The undergraduate major is the second covariate in this study because Evans (2011) discovered that an undergraduate degree major could characterize effective teachers (Evans, 2011). Besides, Darling-Hammond (2000) reported that possession of an undergraduate major in a teaching subject is a positive predictor of teacher effectiveness in advancing students' academic learning gains. Since possession of an undergraduate major in a teaching subject measure teacher efficacy and the participants mostly earned a degree in a variety of fields, the credential could conflict with certification.

Significance of the Study

Biology is a required course for most high school students in the state of Texas (House Bill 5: Foundation High School Graduation Requirements, Texas Education Agency, 2014). Additionally, the state requires most students to pass the State of Texas Assessment of Academic Readiness end-of-course biology, a standardized test required for high school graduation (Texas Education Agency: Students Testing and Accountability, End-of-Course (EOC) Assessments, 2018). Thus, there is the need to pay attention to the quality of biology teachers in state public high schools. Additionally, this study could guide policymakers in creating effective certification policies that could produce teachers with related content knowledge of biology to ensure equity in the distribution of highly qualified biology teachers across most classrooms in the state public schools.

Background and Context

The NCLB requires all teachers of core academic subjects to be highly qualified (Spring, 2011; U.S. Department of Education, No Child Left Behind: A Toolkit for Teachers, 2004) including biology. The law set the initial criteria for selecting highly qualified teachers. However, the law permitted states to define certification requirements for their teacher candidates (U.S. Department of Education, No Child Left Behind: A Toolkit for Teachers (pdf), retrieved 01/15/16). The law made provisions for science teachers to obtain certification in either the broad field of science or in a particular science subject (Spring, 2011; U.S. Department of Education, New No Child Left Behind Flexibility: Highly Qualified Teachers, 2004).

Different states have both similarities and differences in their certification policies and practices. For example, the state of Maryland offers initial standard certification to secondary science teachers in subject-specific fields including biology, chemistry, and physics, and requires the teachers to obtain a passing score in Praxis II subject test (Kaye, 2013). Hence, in Maryland, certification in science is by testing in mostly specific science subjects. Similarly, the states of Florida, Kentucky, New Hampshire, Virginia, and Wyoming require candidates to pass a certification test in particular science subjects including physics, chemistry, and biology (Kaye, 2013).

However, the states of Missouri, Montana, Ohio, Oregon, and Texas offer initial standard licenses in both general science and specific science disciplines (Kaye, 2013). For example, the state of Ohio provides secondary science certification in biology, chemistry, physics, and general science. Similar to states that offer mainly subject certification, Ohio requires candidates to obtain a passing score in Ohio Assessments for Educators (OAE) or

Praxis 11 subject test. Although most states require tests of subject matter knowledge, Montana does not require certification examination for their teachers except out-of-state teachers (Kaye, 2013). Kaye reported that the candidates are required to have a bachelor's degree and to complete teacher preparation program including taking relevant coursework in a teaching subject.

For Texas, which is the focus of this investigation, the following discussion is the process for certifying science teacher candidates. Texas requires teachers to (a) obtain a bachelor's degree, (b) complete an Educator Preparation Program, (c) pass certification exams, (d) submit a state application, and (e) complete fingerprinting (Initial Certification: Becoming a Classroom Teacher in Texas, TEA, 2017). Additionally, a candidate is required to have completed 15 semester credit hours in science or to have scored a passing grade on the Texas Examinations of Educator Standard on the science subject test of interest (State Board for Educator Certification, Subchapter A. Admission to Educator Preparation Programs, Chapter 227.10.). Thus, similar to some other states, Texas offers secondary science certification in both broad fields (composite) science and specific science subjects and requires a certification test (TExES Tests at a Glance, TEA-SBEC, 2017). However, chemistry is the remaining particular subject certification the state offers since biology and physics certifications were discontinued (TExES Tests at a Glance, TEA-SBEC, 2017). Composite science (science 7-12), life science, and physical science certification are some of the secondary science certifications the state offers to biology, chemistry, and physics teachers. However, the state issues certification in composite science most frequently (Ramsay, 2013, 2015, 2017).

Generally, a Texas composite science test consists of 140 multiple-choice questions (20 percent = physics; 20 percent = chemistry; 30 percent = biology and other life science; 9 percent = Earth science; and 6 percent = space science) (TExES Tests at a Glance, TEA-

SBEC, 2017). In contrast, a life science test contains 100 questions (75 percent = biology and other life science) (TExES Tests at a Glance, TEA-SBEC, 2017). While a composite science certification qualifies a teacher to teach a variety of courses, a certification in life science limits a teacher to teach life science courses only (Guidance Document for the Implementation of NCLB Highly Qualified Teacher Requirements, TEA, 2015, p. 41).

Currently, the state assesses content knowledge of pre-service teachers with the Texas Examinations of Educator Standard (TExES). Teachers seeking endorsement in either composite science or life science are both required to obtain the same number of a scaled score to attain a passing grade of 240 out of 300 (Test Results and Score Reporting, Texas Scores and Passing Standards, TEA-SBEC, 2017.

However, the entire composite science test contains only 30 percent of questions in biology and life science domains while the life science test is 75 percent. Thus, the composite teacher seems to have demonstrated less content knowledge of biology and other life science by answering fewer questions. Additionally, by answering fewer questions, the composite teacher seems to have been tested less rigorously for the more difficult biology and other life science issues. Moreover, in-service teachers of most core subjects are eligible to add science certifications by passing TExES in any science certification area of interest (Texas Educators, Additional Certifications, TEA; Kaye, 2013). Thus, certification by exam seems to be an essential criterion for verifying competency of a candidate in teaching a subject of interest.

Rationale

It is relevant to identify the most effective screening process for selecting highly qualified biology teachers since the subject contents in composite science and life science varies in concentration. According to Shuls and Trivitt (2015), a perfect screen for teacher certification keeps out low-quality teachers and allows highly qualified teachers into the teaching field, but a poor licensure screen enables low-quality teachers. Since biology is a required course for high school graduation, the students need highly qualified teachers. Thus, it is essential to identify and to select a certification process that produces efficacious biology teachers.

Additionally, the results of this study add to a rationale that could guide policymakers in retaining, adding, or deleting secondary science certification fields. The state discontinues certification fields and adds new areas periodically. As an example, for certification in the physics and biology fields, two subject-specific certification areas were deleted. This study compared the effectiveness of composite science teachers and teachers with subject-specific certification. Thus, this research provided empirical evidence of the efficacy of composite science teachers (teachers eligible to teach varieties of science courses) and highlighted the importance of subject-specific certification (a certificate that limits teaching in a specific science field).

Purpose

The purpose of this study was to (a) examine the validity and reliability of a modified Teacher Efficacy Beliefs Instrument, (b) compare personal efficacy and outcome expectancy of biology teachers in public high schools in Texas who were certified in composite science with others certified by more concentrated subject-specific tests, and (c) control for teaching experience and undergraduate degree major.

Theoretical Framework

This study stemmed from the work of Bandura (1977, 1986, and 1997). Bandura theorized that personal efficacy and outcome expectancy predict human behavior such as choice of activities, how much effort to put in, and coping abilities in stressful situations. Typically, “People tend to avoid tasks and situations they believe exceed their capabilities but undertake and perform assuredly activities they judge themselves capable of handling”

(Bandura, 1986 p. 393). Though personal efficacy and outcome expectancy are related, different treatment subconstructs are required because individuals may believe that a course of action will produce a particular outcome but question their capabilities to execute the necessary activities to attain the result (Bandura, 1977). Additionally, situational circumstances such as a type of subject matter and an audience influence the level and strength of personal efficacy and outcome expectancy (Bandura, 1977).

In education, personal efficacy and outcome expectancy are termed teacher efficacy beliefs, "the extent to which teachers believe they can affect student achievement positively" (Riggs & Enochs, 1990, p. 5). One will expect composite science certified biology teachers and life science certified biology teachers to be able to advance students' learning gains. Teacher scores on the teacher efficacy belief instrument were used in various studies to measure differences in the teachers' use of effective instructional pedagogy and their ability to increase students' academic achievement. Due to the specific nature of the construct, Riggs and Enochs (1990) deviated from using a general teacher efficacy beliefs instrument and developed Science Teaching Efficacy Beliefs Instrument (STEBI) specific for studies involving teaching science in elementary grades. Over the years, empirical researchers have adapted STEBI in studies involving efficacy of subject teachers such as STEBI-chem (Rubeck, 1990). This research project adapted STEBI-chem, a version of STEBI used in middle grades.

Chapter II

Review of the Literature

This study focuses on the teacher efficacy beliefs of secondary science teachers in Texas. This study intends to compare the teacher efficacy beliefs of Texas secondary science teachers in two certification categories: those with general science certification (composite science) and those with content specified certification.

The literature review explored state certification practices and the following generalizations:

1. Relationships among teaching efficacy factors, and student achievement;
2. Association between content knowledge and instructional approach;
3. Certification exams and association with student performance;
4. Assumption that state certification exams are associated with student performance;
5. Effect of Experience and Professional Development on Teacher Effectiveness; and
6. Discussion about the reviewed literature.

During the literature review, each topic was considered in turn.

Relationships Among Teaching Efficacy Factors and Student Achievement

Bandura (1986) argued that a person requires personal efficacy to perform a task competently, suggesting that composite science and life science certified teachers could need beliefs in their effectiveness to teach biology effectively. Bandura (1977) defined self-efficacy as "the conviction that one can successfully execute the behavior required to produce the outcomes" (p. 79), and outcome expectancy as “a person's estimate that a given behavior will lead to certain outcomes" (Bandura, 1977, p. 79). Personal efficacy and outcome expectancy both predict human behaviors (Bandura, 1986, 1997, 1977).

Rubeck (1990) explained that Bandura's self-efficacy is analogous to personal teaching efficacy and that outcome expectation is comparable to teaching outcome expectancy. A "personal teaching efficacy is a belief in one's ability to teach effectively while teaching outcome expectancy is the belief that effective teaching will have a positive effect on student learning" (Enochs et al., 2000, p. 195). Both "personal teaching efficacy" and "teaching outcome expectancy" constitute teacher efficacy beliefs (Rubeck, 1990).

Several empirical studies in education have explored two-dimensional efficacy theory to study teacher effectiveness. Some studies focused on the impact that personal teaching efficacy and teaching outcome expectancy have on teachers' general ability to teach (Ashton & Webb, 1986; Czerniak & Schriver, 1994). Ashton and Webb (1986) found that teachers with a low sense of efficacy usually doubt their ability to teach. Ashton and Webb conducted their investigation with teachers in high schools who taught mathematics and communication to low-achieving students in a remediation classroom. Thus, the teachers could lack the ability to motivate the low achievers but capable of educating the students in the high-achieving rank, if presented with such an opportunity. Also, the number of participants was small (n=48), making the research not entirely extensible to a larger population. However, other empirical studies supported that teachers with low-teaching efficacy consider low achievers and students from low socioeconomic status are unteachable and do not share responsibility for failures of such students (Ashton, 1982). On the contrary, high efficacy teachers effectively teach low achievers and economically disadvantaged students. Consequently, "the high efficacy teachers take pride in their ability to teach students the low efficacy teachers consider unteachable and also do not ignore the problems poverty students bring with them to the classroom" (Ashton, 1982, p. 185). The studies seemed to suggest the expectation that certified teachers possess the ability to teach students effectively from both high- and low-socioeconomic status. Most disadvantaged students attend public schools. These students especially need teachers with these abilities.

In the area of instructional behaviors, Ashton (1982) reported, “no single variable distinguishes the instructional techniques of low-efficacy teachers from their high-efficacy colleagues” (p. 287). However, many studies posted the counter argument by pointing out differences in instructional strategies between high- and low-efficacy teachers (Cakiroglu, Capa-Aydin, & Hoy, 2012; Czerniak, 1989; Czerniak & Schriver, 1994; Ashton and Webb, 1986; Enochs et al., 2000). According to Czerniak and Schriver (1994), high-efficacy teachers use more student-centered instruction strategies such as observational activities and small group discussion. Low-efficacy teachers employed teacher-centered instructional approach such as reading from a textbook. Moreover, low- and high-efficacy teachers have different goals for applying the strategies (Czerniak & Schriver, 1994). Czerniak and Schriver found that while teachers with low efficacy aimed to minimize behavior problems from students, the high-efficacy teachers use an instructional approach that provides students with hands-on experience, promotes retention, and aids in concept attainment.

Consequently, high efficacy teachers advance students’ learning gains, although not in all measures (Angel & Moseley, 2009; Ashton & Webb, 1986; Hoy & Woolfolk, 1990; Czerniak & Schriver, 1994; Lumpe, Czerniak, Haney, & Beltyukova, 2012). In high school studies, Angel and Moseley (2009) used STEBI to measure personal science teaching efficacy and science teaching outcome expectancy of high school biology teachers. Teachers’ efficacy belief scores were matched to the achievement of their students on an end-of-instruction Biology I test. Angel and Moseley reported that students with teachers who had high-science teaching outcome expectancy scored significantly higher than did students with teachers who had low-science teaching outcome expectancy. However, personal science teaching efficacy of the biology teachers did not affect the scores of the students. The findings support that outcome expectancy could be used to measure teacher effectiveness and that each efficacy subconstruct could influence student academic achievement differently. In a similar study with middle-grade students, Lumpe, Czerniak, Haney, and Beltyukova (2012) reported that personal science-teaching efficacy beliefs were significant and positive predictors of students' science achievement scores, suggesting that personal teaching efficacy could be used to measure teacher effectiveness. The report suggested that STEBI subscales (personal science teaching efficacy and science teaching outcome expectancy) could both predict teacher effectiveness in advancing students' learning in elementary grade.

In a different study, empirical evidence revealed that personal efficacy has social consequences (Wang, Hall, & Rahimi, 2015). Wang, Hall, and Rahimi discovered that personal efficacy was a significant predictor of psychological and physical health in teachers, as well as their intentions to quit teaching (p. 127). The teachers with higher personal efficacy in their ability to engage students in learning reported higher job satisfaction, lower burnout, and less frequent illness symptoms. However, "teachers' beliefs in their ability to use effective teaching strategies corresponded with a stronger intention to quit" (p. 12) suggesting that effective teachers could leave the profession. Similarly, Caprara, Barbaranelli, Steca, and Malone (2006) discovered that teachers' self-efficacy beliefs lead to job satisfaction. Ingersoll (2001) found job dissatisfaction as one of the most reported reasons why teachers quit teaching.

In arguing the rationale for developing the STEBI, Enochs and Riggs (1990) asserted that an investigation of teacher beliefs is key to obtaining a "more complete understanding of teacher behaviors" (1990, p. 3). Gess-Newsome (1999) maintained that differences in teacher beliefs about a teaching subject primarily accounted for overall individual differences in teacher effectiveness. Thus, this study compared personal science teaching efficacy beliefs and science teaching outcome expectancy of high school biology teachers certified in composite science (general science) and subject-area (life science and biology).

Several empirical studies sought ways to improve teacher efficacy beliefs. Some studies revealed that the types of science courses teachers took and the number of college courses they completed are related to teacher efficacy beliefs (Bergman & Morphew, 2015; Menon & Sadler, 2016; Morrell & Carroll, 2003; Schoon & Boone, 1998; Wenner, 1993). Wenner discovered a positive relationship between the number of college courses preservice elementary teachers took in science and their efficacy in teaching science. Although the relationship was moderate, Wenner (1993) was more concerned that only 22 percent of the teachers took more than two semesters of college coursework in science. Wenner believed the deficiency in the number of classes taken in science fields could account for the inability of the teachers to prepare, monitor, and respond to students' needs, especially during laboratory investigations. As a result, Wenner (1993) recommended the integration of science content courses into preservice teacher preparation programs and for a collaboration between the department of elementary education and science departments to ensure that prospective teachers receive adequate content training in science.

However, Wenner did not specify science course types or the number of science-credit course hours preservice teachers could complete to teach science effectively to elementary children. To fill the gap, Bergman and Morphew (2015) conducted an investigation centered on the influence a physical science class had on teacher effectiveness. A class design was specifically for elementary preservice teachers. After a semester of experience in learning the course, the participants showed a statistically significant increase in their self-efficacy and outcome expectancy in teaching science (Bergman & Morphew, 2015). Menon and Sadler (2016) reported similar results with early childhood and elementary teachers. The teachers in Menon and Sadler (2016) had positive changes in their science-teaching efficacy after taking a 5-credit-hour physical science course. The reports seem to suggest that taking focused physical science or more science courses in college could increase teacher effectiveness in teaching science to primary grade students. Menon and Sadler (2016) recommended the explicit design of science-content courses consistent with teaching expectations for pre-service teachers.

It is important to note that most of the studies on the impact of science content knowledge on teacher efficacy beliefs were conducted mostly with elementary teachers. The teachers were expected to have low efficacy in teaching science due to a lack of adequate background knowledge in science. At the same time, empirical research evidenced that it is essential for high school science teachers to have adequate content knowledge in science (Childs & McNicholl, 2007); (Sanders, Borko, & Lockhard, 1993). Some means of obtaining content knowledge of a teaching subject highlighted in the study include completing relevant science coursework and certification. The current certification processes for certifying secondary teachers in Texas require a bachelor's degree. However, specializing in a teaching subject is deemphasized (TEA, Kaye, 2013).

Association Between Content Knowledge and Instructional Approach

Various studies assess content knowledge of teachers with different measures. Some empirical research has used possession of a college degree in a teaching subject (Childs & McNicholl, 2007; Evans, 2011; Goldhaber & Brewer, 2000; Ingersoll, 1999; Shulman, 1986, 1987; Woolnough, 1994). Evans reported that content knowledge correlates with the type of college degree a teacher earned in a teaching subject. Thus, Evans discovered that teachers with undergraduate degrees in mathematics majors showed a significantly higher content knowledge of mathematics than business majors and liberal arts majors. Similarly, Goldhaber and Brewer (2000) supported that the teachers' possession of a subject-specific degree in math significantly predicted the students' math score. To report differently, "math students who have teachers with either bachelor's or master's degrees in mathematics are found to have higher test scores than those whose teachers have out-of-subject degrees (p. 138). In a different study, Ingersoll (1999) discovered that out-of-field teachers have little training or education in the subject they are assigned to teach. Although Ingersoll (1999) had not defined "training" or "education," the assertion highlighted that forms of measures other than an undergraduate college major could be used to assess content knowledge. Teachers could receive "training" or "education" through certification processes, professional development, undergraduate degrees, or completion of some university-credit coursework hours. Childs and McNicholl (2007) discovered during an interview with high school science teachers that the science curriculum, which was outside the subject of the teachers' specialization, included subjects the teachers did not study at the degree or advanced level, or what the teachers perceived as a non-specialized area. The report implies that content teachers could also be non-degree majors.

Other studies have used the type of certification a teacher possessed to assess content knowledge (Sanders, Borko, & Lockhard, 1993; Tretter, Brown, Bush, Saderholm, & Holmes, 2013). Tretter et al. reported that teachers certified in physics scored significantly higher in the physical science assessment test than teachers who took a similar test but possessed a certification in biology, or earth and space science. In the same study, Tretter et al. (2013) discovered that the teachers not certified in science scored lower than the teachers certified in biology or earth and space science. The study highlighted the importance of subject-specific certification (physical science) and the relevance of composite science (biology as well as earth and space science in this context) certification as measures of science content knowledge.

Also, Tretter at al. (2013) assessed content knowledge by the type of college coursework teachers in different grade levels earned and the scores obtained on the test.

According to Tretter at al., high school teachers often take more relevant college science courses in the field of physical science and life science than middle and elementary grade teachers. Also, primary grade teachers often take the least number of courses in the science fields. Tretter at al. reported that the scores teachers obtained on a physical science assessment were related to the type of classes the teachers took in science. The report seemed to suggest an association with the number credit hours teachers earned in physical science and life science with the grade level taught. This association was probably determined by the concentration of science content taught at each grade level. Academic high school science subjects such as biology, chemistry, and physics are more content-based, unlike most middle and elementary grade science. In the lower grades, science is mostly integrated and taught as composite science with less content of each subject. Thus, the performance of science teachers on a content exam and the number of relevant science courses teacher took could correlate with content knowledge. Additionally, the states that certify teachers by exam use scores on tests to assess content knowledge of a candidate.

With different measures, it appears a threshold of content knowledge is required for effective science teaching is not apparent. Nonetheless, most studies revealed that teachers with high content knowledge use effective instructional strategies (Childs & McNicholl, 2007; Gess-Newsome & Lederman, 2001; Sadler & Sonnert, 2016; Sanders, Borko, & Lockhard, 1993; Shulman, 1986; Woolnough, 1994). Childs and McNicholl discovered that teachers who teach within a subject of expertise often use a more student-centered approach, construct alternative ways of explaining concepts to students, and can dispel students' misconceptions. On the contrary, teachers who taught science subjects outside their specialist fields employed more teacher-centered activities and had difficulty explaining scientific concepts to students. Koballa and Crawley (1985) reported that scholars discourage teacher-centered methodologies because the strategies cause elementary and secondary students to develop a negative attitude toward science.

Some studies do not support the association between content knowledge and teacher effectiveness as measured by students' learning outcomes (Goldhaber & Brewer, 2000; Laczko-Kerr & Berliner, 2002; Sadler & Sonnert, 2016; Tretter et al., 2013; Van Driel, Berry, & Meirink, 2014). Goldhaber and Brewer reported, "In science, there is no impact of teachers having subject-specific degrees" (p. 138). However, Goldhaber and Brewer seemed to have grouped all science subjects into one label, science, making it difficult to isolate the influence of teachers' subject matter knowledge on a particular science subject. In high school, basic science disciplines include biology, physics, and chemistry. Physics and chemistry (physical sciences) are pure natural science and mathematics-based fields (Brint, Proctor, Mulligan, Rotondi, & Hanneman, 2012). Biology is a life science and is mostly non-mathematically based. The factors that affect students' outcomes in biology may not necessarily influence their achievements in physics and chemistry subjects.

Certification Exams and Association with Student Performance

Teacher certification status is a measure of teacher qualifications that combines subject matter knowledge with teaching and learning (Darling-Hammond, 2000). As a part of NCLB legislation, core academic teachers including biology teachers are required to obtain state certification (Boyd, Goldhaber, Lankford, & Wyckoff, 2007; No Child Left Behind: A Toolkit for Teachers). "The core science teachers could be certified as teachers in the broad field of science (composite science) or a particular subject such as biology or physics" (Spring, 2012, p. 238).

Many states, including Texas, developed secondary science-subject competency examinations as a part of the certification requirement for verifying a candidate's subject matter knowledge and the knowledge of teaching and learning. The screening criteria for teachers' subject matter knowledge through the certification processes vary across the states, although some have similar practices. A base requirement for high school science teachers is the possession of an undergraduate degree (Kaye, 2013). Some states require candidates to earn an undergraduate degree in a teaching subject in addition to passing a content knowledge test (Boyd, Goldhaber, Lankford, & Wyckoff, 2007). Other states require prospective teachers to obtain an undergraduate major in any field as well as passing a content knowledge exam in a teaching subject area of interest (Boyd, Goldhaber, Lankford, & Wyckoff, 2007). A few states require candidates to obtain an undergraduate degree major in a teaching subject without a testing requirement (Boyd, Goldhaber, Lankford, & Wyckoff, 2007). The state of Texas is among the states that require an undergraduate degree from any field and passing a certification examination (Boyd, et al., 2007; Initial Certification: Becoming a Classroom Teacher in Texas, Texas Education Agency).

Most empirical studies have not yet reached consensus on the most effective certification screening process that ensures only candidates with adequate subject matter knowledge are selected to become teachers. Some believe a candidate's performance on the certification subject test is a valid screen for assessing content knowledge of prospective teachers (Clotfelter, Ladd & Vigdor, 2006; Clotfelter, Ladd, & Vigdor, 2007; Goldhaber, 2007; Goldhaber & Hansen, 2010). Goldhaber studied the impact of teacher performance on the Praxis II curriculum and content licensure tests on reading and math outcome of elementary students. Goldhaber found that the teachers who passed both subject and curriculum tests were more effective in advancing math and reading scores of the students than those who failed the tests. In the study, the minimum score was a combination of the outcomes of the curriculum and subject tests, thus making it difficult to isolate the impact of passing a subject test on student achievement. Nonetheless, when teachers who passed the content test were grouped based on their scores, those teachers who performed at the top quintile were more effective than those who scored at the bottom quintile (Goldhaber, 2007). The report seems to suggest that performance on the certification subject test could be used to screen for teacher effectiveness. Empirical evidence supports the assumption that elementary students of teachers with higher average test scores on the licensure examination achieved higher performances in math and reading (Clotfelter, Ladd, & Vigdor, 2007). The teachers who performed above average raised students' math scores. In contrast, those who scored below average reduced the students' math achievements. Though the report was on the association of teacher performance on the certification test and teacher effectiveness, the findings seem to highlight the importance of paying attention to teacher scores on licensure tests.

Teacher scores on licensure examinations predict achievement outcome of students (Clotfelter, Ladd, & Vigdor, 2006; Goldhaber & Hansen, 2010). Clotfelter, Ladd, and Vigdor discovered that 5th-grade students of teachers with higher average test scores performed higher in math and reading achievement examinations. Goldhaber and Hansen (2010) found that a pass in a licensure test was significantly related to an increase in math grades of the students but not in reading. The finding implies that the minimum score on a certification test could be used to predict teacher effectiveness in improving student outcome but not across all subjects. The minimum score to pass the TExES is the same for both composite science and life science (Test results and score reporting: Test scores and passing standards. TEA, 2017). Candidates are allowed five attempts to pass the test (About the TEXES Tests: Educator Certification Test Retake Policy Change, TEA, 2017). The issue is whether a pass in composite science has a different connotation of teacher effectiveness in teaching biology compared to a pass in life science. The aim of this investigation, therefore, was to measure the efficacy of science teachers who obtained certification in a composite science field and life science or biology and teach biology to students in public high schools in Texas.

It is important to mention that some empirical studies failed to associate certification examinations with teacher effectiveness. Studies suggested there is no direct association between licensure tests and student learning outcomes. Consequently, such testing might not be a good measure of how well a teacher will perform in the classroom (Boyd, Goldhaber, Lankford, and Wyckoff, 2007, p. 59). Boyd et al. asserted that the teachers in a state with a testing requirement and states without licensure testing have a similar academic background (Boyd, Goldhaber, Lankford, and Wyckoff, 2007). However, there were minimal studies that compared the effectiveness of teachers in states with the testing requirement and states without a certification test. Therefore, a pitfall with the discussion was a lack of empirical evidence to support claims about the effectiveness of states with test and non-testing certification requirements.

Relationship Between Certification Generally and Student Learning

States typically issue an initial standard certificate to teachers who have fulfilled most of the state requirements for certification, and such teachers are often considered to be certified (Darling-Hammond, 2000; Laczko-Kerr & Berliner, 2002). In this study, the certified teachers were those who held an initial standard license. Several studies have associated certification and teacher effectiveness in advancing students' academic achievement (Clotfelter, Ladd, & Vigdor, 2007; Cowan & Goldhaber, 2015; Darling-Hammond, 2000; Darling-Hammond, Holtzman, Gatlin & Heilig, 2005; Goldhaber & Brewer, 2000; Laczko-Kerr & Berliner, 2002). Goldhaber and Brewer discovered that the students of teachers certified in science performed higher in a standardized test in science than the students of uncertified science teachers. However, the study did not specify whether the science teachers earned their certification in the broad field (composite) science or possess certification in a subject-specific science field or both. Nonetheless, other studies on the performance of students taught by certified and uncertified teachers in elementary and middle grades revealed similar outcomes (Darling-Hammond, 2000; Laczko-Kerr & Berliner, 2002; Darling-Hammond, Holtzman, Gatlin & Heilig, 2005; Cowan & Goldhaber, 2015). Laczko-Kerr and Berliner identified significance in the standardized test scores in reading, math, and language arts of elementary and middle-grade students taught by certified and uncertified teachers. Laczko-Kerr and Berliner reported that the students taught by certified teachers outperformed students taught by uncertified teachers in reading, math and language art. Similarly, Darling-Hammond et al. reported that teachers without certification slowed student progress in achievement tests over the course of a year by one-half month to a whole month in grade-equivalent terms. The report from secondary and elementary grades studies appear to support an association between certification and student academic progress. Additionally, Cowan and Goldhaber (2015) obtained a positive relationship between teacher effectiveness and most of the different varieties of standard certificates offered to elementary and middle-grade teachers, but certifications were issued to teachers in diversified departments and not within a particular field such as science. Most studies have not compared the efficacy of teachers holding varieties of certification within an academic department, such as science and teaching similar courses.

Other studies supported that teachers certified through a more rigorous National Board Certification program were more effective than teachers certified through the state (Clotfelter, Ladd, & Vigdor, (2007), implying that the rigor of a certification program could influence the efficacy of certified teachers. Also, the report seems to indicate that certified teachers could have different levels of effectiveness. Studies evidenced association between teachers certified in a particular subject area and outcome of students' learning but with no consistent relationship in all subjects. For example, Clotfelter, Ladd, and Vigdor (2007) discovered that math scores of students taught by math-certified teachers increased significantly, but certification in biology did not affect the biology grades of biology students. The report seems to highlight the importance of subject-specific certification. Similarly, Sanders, Borko, and Lockhard (1993) supported the relevance of subject-specific certification in teaching and learning. Sanders, Borko, and Lockhard discovered that teachers certified in specific subjects including biology, chemistry, earth science, and mathematics acted like experts in teaching the subjects. The teachers had confidence and ability to elaborate on a student's idea; give a broader range of alternative explanations; dispel misconceptions from students, and use student-centered activities. On the contrary, Sanders, Borko, and Lockhard reported that the teachers were incompetent in teaching other subjects outside their certification field. The teachers lacked confidence and ability to elaborate on students' ideas; and employed seatwork activities including worksheets during instruction. Again, Koballa and Crawley (1985) were critical of seatwork instructional practices and highlighted that such methodology "does little to enhance positive attitude development among elementary and secondary students" (p. 229). It is noteworthy that the teachers in the Sanders, Borko, and Lockhard study possessed certification in a specified science subject. A teacher certified in the composite science field could behave as an expert in teaching most of the potential five courses or act like an expert in teaching some of the science course and behave as a novice in teaching the other subjects. Thus, it is essential to study the effectiveness of composite-science certified teachers that most studies have not addressed.

It is noteworthy to mention that not all studies support that earning a standard certification is essential in selecting qualified teachers (Goldhaber & Brewer, 2000; Kane, Rockoff, & Staiger, 2007; Wiseman & Al-bakr, 2013). Goldhaber and Brewer discovered that the students of teachers who held emergency certification (a temporary license issued to teachers who have not gone through an educator preparation program or sat for any certification exam) did as well as students of teachers who held a standard license. Goldhaber and Brewer reported that the school districts had more carefully screened the "teachers with emergency credentials for ability or for content knowledge than those with standard certification" (Goldhaber & Brewer, 2000, p. 139). The report appears to suggest that teachers could be screened for ability and content knowledge by means other than certification processes. However, Goldhaber and Brewer (2000) did not discuss a screening process alternative to certification. In a similar study, Kane, Rockoff, and Staiger (2007) observed that math and reading scores of elementary and middle-grade students who were taught by certified teachers were just slightly higher than the scores of students who were taught by uncertified teachers. Consequently, Kane, Rockoff, and Staiger recommended to educational policymakers to seek alternative ways of screening out less qualified teachers other than through the certification processes. The problem remains that the studies failed to suggest an alternative to certification as a screening process for teacher quality.

Effect of Experience and Professional Development on Teacher Effectiveness

Several studies examined teaching experience and professional development on teacher effectiveness (Cakiroglu, Capa-Aydin, & Hoy, 2012; Childs & McNicholl, 2007; Clotfelter, Ladd, & Vigdor, 2007; Darling-Hammond, 2000; Shulman, 1987). Darling-Hammond discovered from a literature review that teacher effectiveness and teaching experience are not always linear. According to Darling-Hammond, the teachers with less than three years of teaching experience were often less competent than veteran teachers. However, "the benefit of experience appears to level off after about five years" (p. 7) especially if veteran teachers become tired of teaching or discontinue learning and growing in the knowledge of a teaching field. Darling-Hammond referenced the work of Rosenholtz (1984) on the influence of professional development and collaboration on the performance of veteran teachers. Additionally, Darling-Hammond reported, "very well-prepared beginning teachers can be highly effective" (p. 7). She cited the work of Andrew and Schwab (1995), and Denton and Peters (1988) who found that graduates of an educator preparation program that requires participants to have a bachelor's degree in a teaching subject, master's degree in education, and one year of student teaching were as effective as veteran teachers. Additionally, Darling-Hammond (2000) reported that experience correlated with certification status and suggested that experience may be a confounding variable in a certification study. The report by Darling-Hammond (2000) seemed to indicate that professional development or earning an advanced degree while teaching or taking coursework related to a teaching field and collaborating with colleagues could improve teaching effectiveness of experienced teachers.

However, Clotfelter, Ladd, and Vigdor (2007) discovered in elementary grades that "teachers with more experience are more effective in raising student achievement in math and reading than those with less experience" (p. 675), but with "more than half the benefit occurring during the first couple of years of teaching" (p. 676). Similarly, in high school, Clotfelter, Ladd, and Vigdor (2007) discovered that the "veteran teachers are more effective than novice teachers, "but beyond the first couple of years, more experienced teachers are no more effective than those with a couple of years of experience" (p. 19). In a report consistent with Darling-Hammond (2000), Clotfelter, Ladd, and Vigdor attributed the ineffectiveness of experienced teachers to teacher attrition. Attrition leaves out less competent teachers in the profession or those veteran teachers who do not continue to learn on the job. The study by Clotfelter, Ladd, and Vigdor in elementary grades and in high school both support that experienced teachers are consistently no more effective than novice teachers. The teacher who possesses certification in composite science or in life science is expected to engage in academic work that enhances knowledge of a teaching subject since the tests were designed to assess the competency of knowledge and skills of a beginning teacher.

However, Child and McNicholl (2007) were surprised that experienced teachers and novice teachers encountered similar challenges when each taught a science subject outside their field of specialty, a report that suggests teacher competency and experience vary with the nature of a teaching subject. Minimal studies established that experienced and novice teachers will always encounter similar challenges in most science teaching situations. Therefore, studies have not reached consensus on the effect of experience on teaching effectiveness. Experience is the confounding variable in this study.

Discussion

The literature review revealed that teaching experience, degree major, and certification were teacher credentials that influenced teacher effectiveness. In this study, certification is the independent variable while teaching experience and degree major are the control variables. Although different studies highlighted the relationship between teaching experience and teacher effectiveness, studies have yet to identify a causal relationship between experience and teacher quality. Additionally, experience has a minimal effect on teaching a subject outside a teacher's discipline of expertise (Child & McNicholl, 2007). Child and McNicholl discovered from interviewing novice and veteran teachers that teachers in both experience groups encountered challenges when they taught a science subject outside their field of specialty. The competencies tested on science tests are designed to assess whether a beginning teacher has the requisite knowledge and skills to teach biology effectively. However, studies have yet to establish a causal relationship between experience and a teachers' subject matter knowledge.

Moreover, a test of subject matter knowledge is a part of the certification process in Texas, and the teachers are not required to earn an undergraduate college degree in a teaching subject. It is likely that a composite science teacher could be an instructor in a science subject in which he or she earned an undergraduate degree major as well as being an instructor in a science subject in which he or she does not hold a baccalaureate degree or higher. Studies have used possession of a college degree in teaching a subject to measure content knowledge (Evans, 2011) and teacher effectiveness in advancing students' learning (Goldhaber & Brewer, 2000). Evans discovered that mathematics majors showed a significantly higher content knowledge of mathematics than business majors and liberal arts majors. Goldhaber and Brewer reported that teachers' possession of a subject-specific degree in math significantly predicted the students' math score but such specified knowledge does not affect science. The report seems to suggest that quality science teachers could be non-science majors. An empirical study could further explore this claim.

Additionally, Texas requires science teachers to pass a test of subject matter knowledge before obtaining a standard license. Clotfelter, Ladd, and Vigdor (2006) reported that teacher-licensure test scores consistently predict the achievement outcome of students. The composite science and subject-specific science tests (life science) have the same minimum passing score. Consequently, it is difficult to assess the impact of the teachers' performance on their effectiveness based only on the score. Besides, the proportion of questions differs per a reference subject in a certification exam. If a college major and experience are blinded, do composite science and life science certification equally produce teachers who can improve students' learning gains in biology? An investigation of this question should be undertaken.

Again, in high school, Goldhaber and Brewer (2000) found that the students of teachers certified in science performed higher in a standardized test in science than students of uncertified science teachers. Several studies in middle and elementary grade support that certified teachers are more effective than their uncertified counterparts (Cowan & Goldhaber, 2015; Darling-Hammond, 2000; Laczko-Kerr & Berliner, 2002; Darling-Hammond, Holtzman, Gatlin & Heilig, 2005). However, not all studies support that possession of standard certification is essential in selecting qualified teachers (Goldhaber & Brewer, 2000; Kane, Rockoff & Staiger, 2007; Wiseman & Al-bakr, 2013). Goldhaber and Brewer reported that students of teachers carefully screened for their ability or content knowledge, without the usual standard certification process, perform as well as students of teachers who hold a standard license. The report appears to suggest that a teachers' ability and content knowledge could be used in place of a standard certification process to screen-out unqualified teacher candidates. However, researchers did not address the question of how teachers could be selected based on ability and content knowledge. An answer to this question is needed. Also, Clotfelter, Ladd, and Vigdor (2007) reported that teachers certified through a more rigorous National Board Certification program were more effective than teachers certified through the state program. This result suggests the rigor of a certification program could impact the efficacy of certified teachers. This claim also needs to be examined.

Several studies highlighted the importance of teacher certification including licensure exams in measuring a candidate's content knowledge. Most certified teachers in secondary and elementary grade levels were reported to be more effective than uncertified teachers (Cowan & Goldhaber, 2015; Goldhaber & Brewer (2000); Darling-Hammond, 2000; Laczko-Kerr & Berliner, 2002; Darling-Hammond, Holtzman, Gatlin & Heilig, 2005). The implication is that policymakers could continue to require certification for teacher candidates with a focus on best practices. Studies highlighted subject matter certification, certification through a rigorous program, and teacher performance in licensure tests are effective processes for screening candidates' content knowledge through a certification process. The implication is for states and policymakers to reevaluate their certification program to address research-based evidence components of an effective certification process.

It is important to mention limitations of the current study. First, the scope of the study is highly limited to address most of the gaps identified in the literature. Students' learning seems the most important measure of effective teaching. However, a comparison of the efficacy of broad and subject-specific certified science teachers in improving students' learning gains is beyond the scope of this study. The study employed a proxy measure of teacher effectiveness, such as teacher efficacy beliefs. Direct matching of student performance with certified teachers seems to have been a more reliable test of the effectiveness of different categories of certified teachers. Since biology is one of the required state tests for high school graduation, a quantitative study to compare the actual performance of students of teachers certified in composite science with those certified in a subject-specific field such as life science or biology will compensate for the limitations of the current study. Moreover, instructional differences are another important measure of teacher effectiveness, but the current study did not include observation of individual teachers' instructional practices. A qualitative study such as interviews and observations would support the results of the current research. Finally, the survey methodology employed in the present study is known to produce subjective data. The validity of the results is highly dependent on the participants' eliciting an honest and accurate response. Additionally, the possibility of one teacher having multiple certifications could introduce errors in the statistical computation and potentially skew results of the survey.

Research Question

Does a significant difference in personal efficacy or outcome expectancy exist between biology teachers certified in composite science with biology teachers certified in a more subject-specific science certification field, controlling for an undergraduate degree major and teaching experience?

Chapter III

Methodology

Research Design

This study is a correlational design that used data from an online survey to examine the validity and reliability of a modified instrument and to compare the personal efficacy and outcome expectancy of biology teachers certified in composite science with biology teachers certified in a subject-specific science field. The method was appropriate for this study because correlational study allows for a comparison of relationships between two or more groups in a nonexperimental quantitative design (Slavin, 2007).

The pilot study (Appendix G) discussed complete instrumentation including the processes of modifying STEBI-chem to obtain the High-School Science Teaching Efficacy Belief Instrument (HS-STEBI) for physics and biology, namely, HS-STEBI-phys and HS-STEBI-bio, respectively. Later, a third scale, HS-STEBI-chem was adapted. Three survey instruments, HS-STEBI-phys, HS-STEBI-bio, and H-STEBI-chem, were distributed simultaneously to in-service physics, biology, and chemistry teachers to gather information about personal efficacy and outcome expectancy in teaching each respective science subject. The demographic data collected from the participants included ethnicity, certification, undergraduate degree major, and teaching experience. However, only data from the biology group were analyzed in this study. Participant scores were used to examine the validity and reliability of the modified Science Teaching Efficacy Belief Instrument and to compare personal efficacy and outcome expectancy of composite teachers and life science certified biology teachers, controlling for teaching experience and undergraduate college major.

In this study, the life science certification field was considered subject-specific because TExES life science contains 75 percent of the questions in biology and other life science fields. Because the biology test was phased out, the composition of the exam was difficult to ascertain. Thus, biology certification was not analyzed. Similarly, since the TExES chemistry and physical science do not contain questions in biology or other life science domains, the two certification fields were not part of the analysis. Therefore, only composite science, life science, and biology certifications were analyzed.

The dependent variables were personal efficacy and outcome expectancy. The independent variable was certification. The undergraduate major and the teaching experience were the control variables. The dependent variables and teaching experience variables are continuous variables. The independent variable, certification, is a categorical variable with six subscores: composite science, life science, physical science, biology, physics, and other. In addition, the undergraduate variable consisted of three subscores: physical sciences, biological sciences, and other. The teaching experience variable employed four teaching intervals: 0 to 5 years, 6 to 10 years, 11 to 15 years, and over 15 years.

Sample

Participants were in-service biology teachers who taught biology in the 2017-2018 school year in Texas public high schools. Data collection took place during the fall of 2017. A total of 11,665 email addresses of in-service science teachers were obtained (8,419 from Market Data Retrieval and 3,246 collected by the researcher). Qualtrics online survey software was use to merge the Market Data Retrieval (MDR) email list and the researcher's email list into one single email list. Combining the two email lists was possible because Qualtrics recognized and highlighted duplicated emails and allowed the researcher to "click" on "consolidate duplicate" to remove the duplicate. The intent of the consolidation process was to avoid distribution of two or more surveys to the same participant thereby avoiding the possibility of a participant responding twice to the survey. Overall, the goal of the researcher was to recruit only physics, biology, and chemistry teachers, but science teachers often teach multiple science courses. Thus, the type of science taught by each participant was not a significant factor during the recruitment process.

Data Collection

Qualtrics, a survey platform, collected the data online. Qualtrics distributed the survey online to 11,665 science teachers in the fall of the 2017-2018 academic year. Science teacher sampling did not consider the teaching subject. The Qualtrics 'skip logic' feature was used to exclude non-physics, non-biology, and non-chemistry samples. The intent was to include only physics, biology, and chemistry teachers. First, each participant responded 'yes' or 'no' to the two recruitment questions. (a) Are you certified by the state of Texas to teach science in high school? (b) Do you teach in a public high school in Texas? Participants who answered 'no' to the two recruitment questions skipped to the end of the survey and did not participate in the study.

By contrast, participants who responded 'yes' were included to participate in the study and were directed to respond to either the physics, biology, or chemistry survey. The next question after the recruitment questions was, “Do you teach any section physics course this school year (2017-2018)?" and participants who responded “yes” answered the physics survey but those who responded ‘no’ skipped to the biology survey. A similar question asked in the biology section was, “Do you teach any section biology course this school year (2017-2018)?” Again, participants who answered 'yes' responded to the biology survey and those who responded ‘no’ skipped to the chemistry section. Next, the remaining sample in the chemistry section responded to the question, “Do you teach any section chemistry course this school year (2017-2018)?” Again, the sample who responded 'yes’ answered the chemistry survey and those who responded 'no' skipped to the end of the survey and exited. Thus, the ‘skip logic’ allowed only physics, biology, and chemistry teachers to complete the survey.

The software programs, Statistical Package for the Social Sciences (SPSS) 25.0, and *SPSS* Analysis of a Moment Structures (AMOS) 25 were used to analyze the imported data file. Responses from the participants who answered 'yes' to both recruitment questions were analyzed. A total of 1,618 participants completed the survey. The sample included 135 who answered 'no' to either or both recruitment questions but also completed the survey. However, scores associated with the 'no' sample participants were deleted. This study analyzed and reported only on teacher-biology data, although data were collected from biology, chemistry, and physics teachers.

Analytical Techniques

The researcher considered it necessary to re-evaluate the validity and reliability of HS-STEBI-bio in the current study for four reasons. First, item 8 was omitted from the scales in the pilot study and was reintroduced in the present study. The omitted variable could affect the psychometric properties of the instrument. Second, the pilot study was conducted with a convenient sample, making the study less generalizable to the science teacher population. Third, the sample size was small in the pilot study, n = 46 biology teachers. The number of participants increased in the current study. The difference in sample size could affect the psychometric properties of the scale. Thus, the validity of each HS-STEBI-bio was re-assessed using Principal Component Analysis and Confirmatory Factor Analysis. Next, the internal consistency of the subscales in HS-STEBI-bio was evaluated using Cronbach's alpha. Then, a hierarchical multiple regression analysis was conducted to compare composite science-certified teachers and life-science certified biology teachers while controlling for their undergraduate degree major and teaching experience. Multiple regression analysis was selected; because, the analysis "evaluates the effects of one or more independent variables on a dependent variable, controlling for one or more covariates" (Slain, 2007, p. 97). Before conducting the analysis, the categorical variables were dummy coded.

Ethical Issues

The Institution Review Board at the University of Houston approved both the current study and the pilot studies. Informed consent was presented to participants to read and acknowledge before responding to the survey questions.

Chapter IV

Analysis and Results

The purpose of this study was to examine the validity and reliability of STEBI-bio, a modified instrument for measuring personal efficacy and outcome expectancy of biology teachers certified in composite science, biology, and life science in the state of Texas. Also, the aim was to compare personal efficacy and outcome expectancy of biology teachers certified in composite science with the teachers holding certification in more subject-specific science fields (life science or biology). The following research question guided the study: Does a significant difference in personal efficacy or outcome expectancy exist between biology teachers certified in composite science with biology teachers certified in more subject-specific science certification field (life science or biology) controlling for an undergraduate degree major and teaching experience?

Data Screening

The survey responses were imported from Qualtrics into *SPSS* 25.0 for analysis. The two recruitment questions were: (1) Are you certified by the state of Texas to teach science in high school? (2) Do you teach in a public high school in Texas? The two questions were presented to each participant before the survey. The participants who responded "no" to either of the two recruitment questions were deleted (7.7 percent) because this study was intended for biology teachers certified by the state of Texas and who also teach in public high schools in Texas. Thus, the data were analyzed from participants who answered "yes" to both recruitment questions. A total of 1,618 completed the survey, and 135 answered "no" to either or both recruitment questions. The missing values were 7.7 percent and mainly from teachers who indicated "not a public high school teacher" or "not certified to teach in the state." Other cases with missing values were retained. However, the analysis was often conducted by selecting "exclude cases listwise" that removes all cases with missing values in a particular analysis. The option was shown to ensure each participant had values for personal efficacy and outcome expectancy. Additionally, 5.3 percent of the participants who obtained certification by methods other than taking a certification exam were deleted because the focus of this investigation was on teachers who took a certification test.

The dataset for conducting Confirmatory Factor Analysis was prepared separately from the dataset used for running the other analysis. For the Confirmatory Factor Analysis (CFA), all cases with missing values had to be deleted before calculating the Goodness of Fit Index. Thus, the cases with missing values were deleted from the dataset. A boxplot identified outliers. The outliers were removed before conducting the CFA tests. The other tests were conducted by selecting the “exclude cases listwise” option to ensure each participant had scores for both personal efficacy and outcome expectancy variables. Again, a boxplot was used to identify outliers in the two dependent variables, personal efficacy and outcome expectancy. As mentioned, the cases with outliers were removed. An assumption of normality was essential for the multivariate tests employed in this study. Consequently, the dependent variables were screened further for normality using skewness and kurtosis tests. The skewness results, 1.23 for the personal efficacy variable and .41 for the outcome expectancy variable, indicated a normal distribution. Similarly, the kurtosis result, .80 for the outcome expectancy variable, supported normality. However, the kurtosis result, 1.61 for the personal efficacy variable, deviated slightly from a normal distribution. According to Gamst, Meyers, and Guarino (2008), "skewness or kurtosis zero value or close to zero indicate a normally distributed variable. Values greater than +1 or less than -1 are considered indicative of a non-normally distributed variable" (p. 56). Thus, the skewness results revealed the personal efficacy and outcome expectancy variables were normal. The kurtosis results showed the outcome expectancy variable was normal, but the personal efficacy variable was non-normal. The Kolmogorov-Smirnova (K-S) and Shapiro-Wilk (S-W) tests indicated that the independent variables were non-normal, p <.05. However, K-S and S-W tests are sensitive to large sample size and "can be significant even for small and unimportant effects" (Field, 2013, p. 184). The normality test was followed up with Quantile-Quantile plots. The Quantile-Quantile (Q-Q) plots showed that most of the quantiles in the outcome variable in Figure 1 are very close to the diagonal line that shows that the variable is normal. Similarly, the Q-Q plots in Figure 2 show that most of the quantiles on personal efficacy variables are close to the linear line. Thus, the Q-Q plots indicated that the two dependent variables were mostly normally distributed.

Descriptive Statistics

A total of 562 biology teachers participated in the study, with 177 males and 365 females reporting their gender. Females constituted 67.2 percent of the participants. Among the different ethnic groups that participated in the study, the majority was White, 65.1 percent. Collectively, 94.7 percent of the teachers obtained certification in science by taking a test, and only 5.3 percent did not take a test to become certified. While 51.5 percent of the teachers obtained certification through an alternative route, 43.5 percent obtained certification through traditional methods and 5.0 percent obtained certification through "other" routes. Additionally, participants reported whether each taught biology in urban, suburban, or rural schools. The highest percentage of the biology teachers taught in suburban schools, 44.1 percent. The distribution of participants in rural and urban school was closely similar. Table 3 shows the demographics of the study participants.

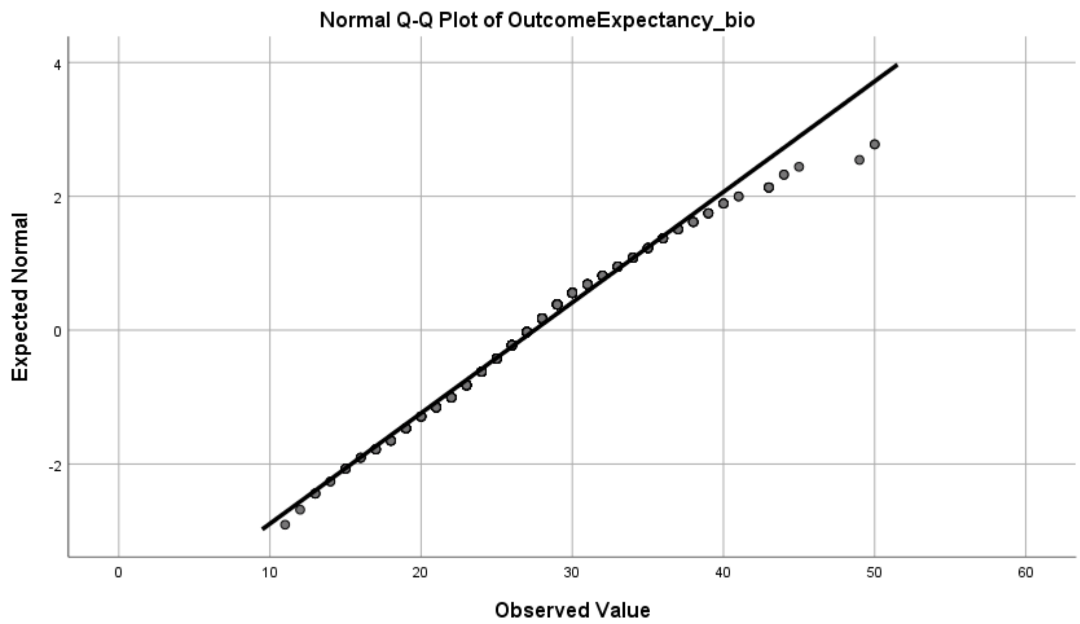

Figure 1. Q-Q plot of outcome expectancy in teaching biology.

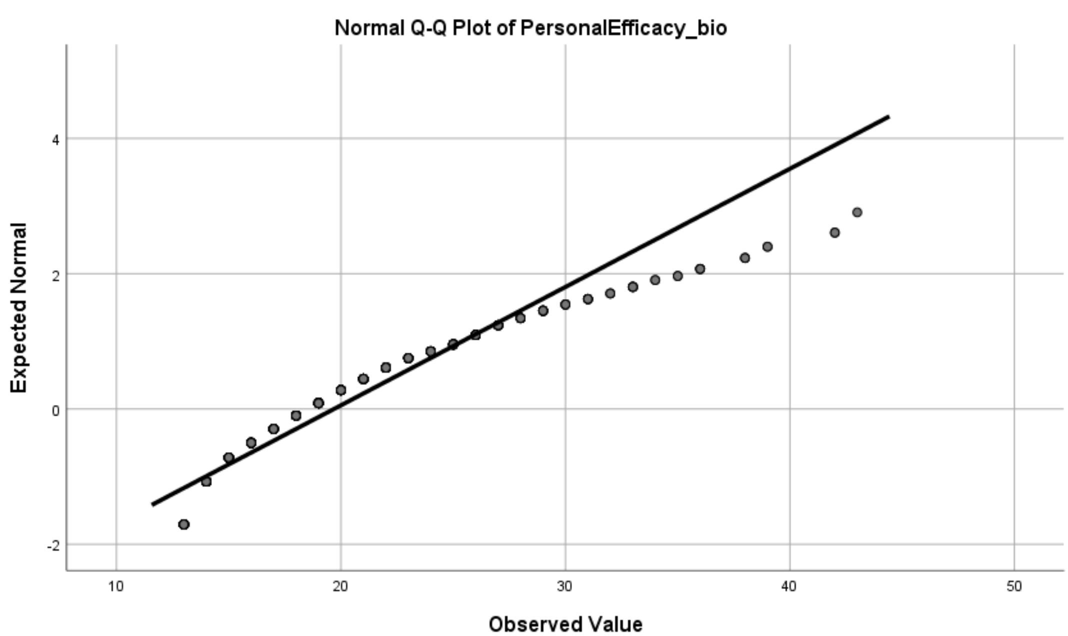

Figure 2. Q-Q plot of personal efficacy in teaching biology.

Coding Certification Types

In the survey, each participant provided varieties of types of teaching certification earned. However, each teacher was assigned to only one certification group and could not belong to two or more groups. Fourteen certification groups listed below were generated from varieties of certifications the teachers listed. Then, the groups were divided into four categories: life science, biology, composite science, and other. The groups that belong to each category are displayed in Table 1. This study assumed that a participant who took the TExES test with the highest concentration of questions in biology and other life science fields would be most qualified to teach biology. Consequently, coding centered on the concentration of biology and other life science domains in the current TExES certification tests. Therefore, a teacher who earned certification in life science only or life science with any other type of certification was coded "life science." A participant was assigned "life science" code if they possessed life science and biology certification. The decision was made because the composition of the life science test is known and life science certification is currently available to teachers, while biology certification was discontinued.

The biology test was discontinued, making it difficult to obtain information about the nature and composition of the test. The biology certification and life science certification were not combined because teachers earned certification in both life science and biology, indicating the two tests may be different. Moreover, the biology and life science certifications categories recorded significant negative correlation in regression, $r = -.40$, $p < .001$ (see Table 10), an indication that biology and life science certification could be dissimilar. Therefore, biology and life science were coded differently. A "biology" code was assigned to each teacher reporting either biology only or biology with any other type of certification except life science. A teacher was assigned a "composite science" code if that teacher obtained certification in composite science only with no biology or life science. The code “other” was assigned to a teacher with a non-science certification. Table 1 shows the certification codes and certification groups in each code. Table 2 shows the descriptive statistics of participants in each group.

Certification Groups:

1. Life science only
2. Life science and composite Science
3. Life science and biology
4. Life science, Composite science, and Biology
5. Life science, and Physical science (chemistry, physics, or physical science)
6. Life science, Composite science, Biology and Physical science
7. Life science, Biology, and Physical science
8. Life science Composite science, and Physical science
9. Biology only
10. Biology and Composite science
11. Biology and physical science (chemistry, physics or physical science)
12. Biology, Composite science, Physical science (chemistry, physics or physical science)
13. Composite science only
14. Other (Non-Science)

Table 1

Certification Codes and Teachers' Certifications

Certification Codes	Certification Groups
Life Science	
	Life Science only
	Life Science and Composite Science
	Life Science and biology
	Life Science, Composite Science, and Biology
	Life Science and Physical Science (Chemistry, Physics or Physical Science
	Life Science, Composite Science, Biology, and Physical Science
	Life Science, Biology, and Physical Science
	Life Science, Composite Science, and Physical science
Biology	
	Biology only
	Biology and Composite Science
	Biology and Physical Sciences (Chemistry, Physics or Physical Science)
	Biology, Composite Science, and Physical Science
Composite Science	
	Composite Science only
Other	
	None-Science

Coding Teaching Experience

The number of years of teaching experience each participant reported in the survey was coded as novice: (0 - 5 years) = 1, intermediate: (6-10 years) = 2, veteran: (11 years and up) = 3. The coding was slightly consistent with Childs and McNichol (2007) and other studies on teaching experience and teacher effectiveness (Clotfelter, Ladd & Vigdor, 2007; Darling-Hammond, 2000). Childs and McNichol grouped the participants with 0 to 5 years teaching experience as novice and teachers with more than five years teaching experience as veterans, and within the veterans' group, four teachers had more than ten years teaching experience. Additionally, Clotfelter, Ladd, and Vigdor (2007) reported that teaching effectiveness and teaching experience are non-linear because, for some number of years, novice teachers are less effective than veteran teachers. Thus, the participants were assigned into one of three different experience groups including intermediate, in an attempt to examine when an effect of experience could determine teacher effectiveness. The descriptive statistics in Table 3 revealed the percentage of novice teachers in this study was slightly higher than teachers in either the veteran or intermediate groups.

Coding Undergraduate Major

The college majors reported by participants were coded: physical sciences = 1 (physics, chemistry, engineering, geology, earth and space science); biological sciences = 2 (biology, biochemistry and applied biological sciences); and other (non-physical or non-biological science major). The descriptive statistics test results in Table 3 revealed that 73.6 percent of biology teachers obtained undergraduate college major in biology or a related field.

Table 2

Descriptive Statistics of Certification Groups

Certifications	Frequency	Percent
Composite Science Only	223	41.3
Life Science Only	128	23.7
Life science Composite Science	42	7.8
Life Science and Biology	29	5.4
Life Science, Composite Science, and Biology	5	0.9
Life Science and Physical Science	8	1.5
Life Science, Composite Science, Biology, and Physical Science	4	0.7
Life Science, Biology, and Physical Science	6	1.1
Life Science, Composite Science, and Physical Science	2	0.4
Biology Only	54	10.0
Biology and Composite Science	19	3.5
Biology and Physical Science (chemistry, physical science or physics)	10	1.9
Biology, Composite Science, and Physical Science (chemistry, physical science or physics)	9	1.7
Non-Science	1	0.2

N = 540

Table 3

Demographics of Study Participants

	Frequency	Percent
Ethnicity		
Caucasian/White, non-Hispanic	352	65.1
African American/Black, non-Hispanic	57	10.5
Hispanic	96	17.7
Other	36	6.7
Gender		
Male	177	32.8
Female	363	67.2
Undergraduate Degree Major		
Physical Science	23	4.3
Biological Science	398	73.6
Other	120	22.2
Teaching Experience		
0 to 5 years	219	39.7
6 to 10 years	122	22.1
10 Years Plus	211	38.2
Certification Route		
Alternative Route	278	51.5
Traditional Route	235	43.5
Other	27	5
Certification Test		
Certified by Testing	514	94.7
Not Certified by Testing	29	5.3
Year Certification Test was Taken		
0 to 5 Years	154	29.8
6 to 10 Years	114	22.1
11 to 15 Years	91	17.6
15 Years and Up	157	30.4
School Location		
Urban	162	29.9
Suburban	239	44.1
Rural	141	26.0

Instrumentation

Principal Component Analysis

Before conducting the PCA, negatively worded items (3, 10, 13, 19, 21, 22, 24, and 25) were reverse-coded. For example, item 25 (Even teachers with good teaching abilities cannot help some students learn biology.) is a negative item and scored in the survey as: 1 = strongly agree, 2 = agree, 3 = neither, 4 = disagree, and 5 = strongly disagree but reverse-scored as 5 = strongly agree, 4 = agree, 3 = neither, 2 = disagree, and I = strongly disagree. A PCA with varimax orthogonal rotation was conducted on the 25-item HS-STEBI-bio using IBM SPSS statistics. The number of principal components to extract was fixed at two because of the prior theory that efficacy beliefs are two subconstructs, personal efficacy, and outcome expectancy (Bandura, 1977, 1997). In addition, the existing STEBI is a two-subscale instrument (Riggs & Enochs, 1990; Rubeck, 1990). Then, a varimax orthogonal rotation was chosen because the technique allows variables that correlate strongly with the first principal component to correlate weakly with a second principal component, thus making it easy to identify the variable that defines each principal component. Moreover, the two subscales, personal efficacy and outcome expectancy subscales, measure different subconstructs (Bandura, 1977), and varimax orthogonal rotation functions well with principal components not highly correlated.

The scree plot test showed inflexion that justified retention of two principal components (Figure 3). Thus, a decision that two principal components could be a solution was based on scree plot results and prior theory on STEBI (Riggs & Enochs, 1990) and the personal efficacy theory (Bandura, 1977). The first principal component had an eigenvalue of 5.47 and explained 21.89 percent of the total variance, and the second component recorded an eigenvalue of 3.27 and accounted for 13.07 percent of the total variance. The results were comparable to those obtained by Riggs and Enochs (1990).

Table 4 shows loadings on each principal component. A total of 13 items loaded into the first principal component and the items were consistent with variables that constituted factor one in STEBI-chem (Rubeck, 1990). Similar loading consistency was observed for the second component, 12 items loaded in to the second principal component. Each item recorded loadings .3, the lowest coefficient for retaining an item (Feld, 2013). The 13 variables (2, 3, 5, 6, 8, 12, 17, 18, 19, 21, 22, 23, and 24) defined the first principal component. Also, 11 items (1, 4, 7, 9, 10, 11, 13, 14, 15, 16, 20, and 25) defined the second component. However, item 13 seemed to cross-load to both principal components and, consequently, was removed. The first principal component was named "Personal Efficacy in Teaching Biology" while the second principal component was labeled "Outcome Expectancy in Teaching Biology." The subscales were initially named in the pilot study.

The internal consistency reliability of both Personal Efficacy in Teaching Biology (PETB) and Outcome Expectancy in Teaching Biology (OETB) subscales was conducted using Cronbach's alpha. The PETB subscale recorded overall alpha of .81. All items reached Corrected Item-Total Correlation of .3 and above. Additionally, the overall reliability of OETB subscale was good, .80, and each variable registered Corrected Item-Total Correlation of .3 and above, except the item 10. The Item-Total Correlation and overall reliability test results are displayed in Table 4.

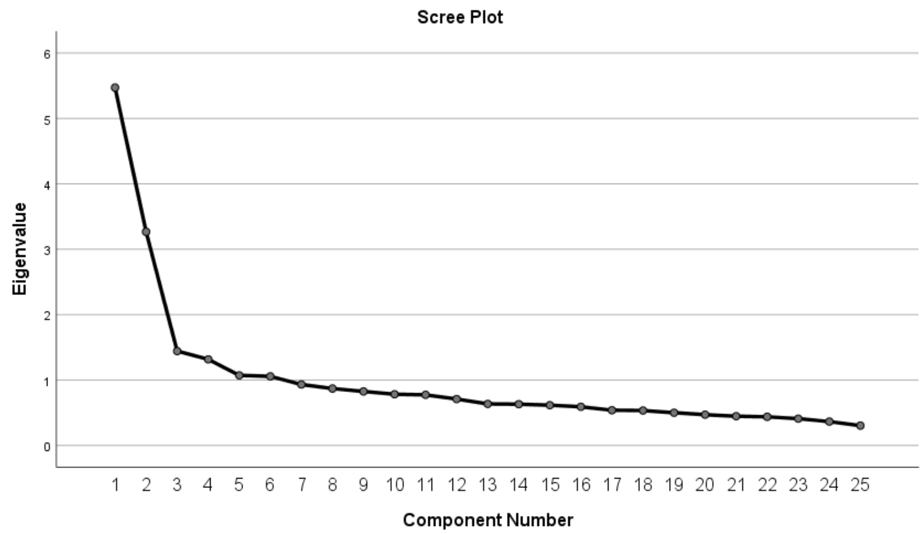

Figure 3. Scree plot of 25-item HS-STEBI-bio.

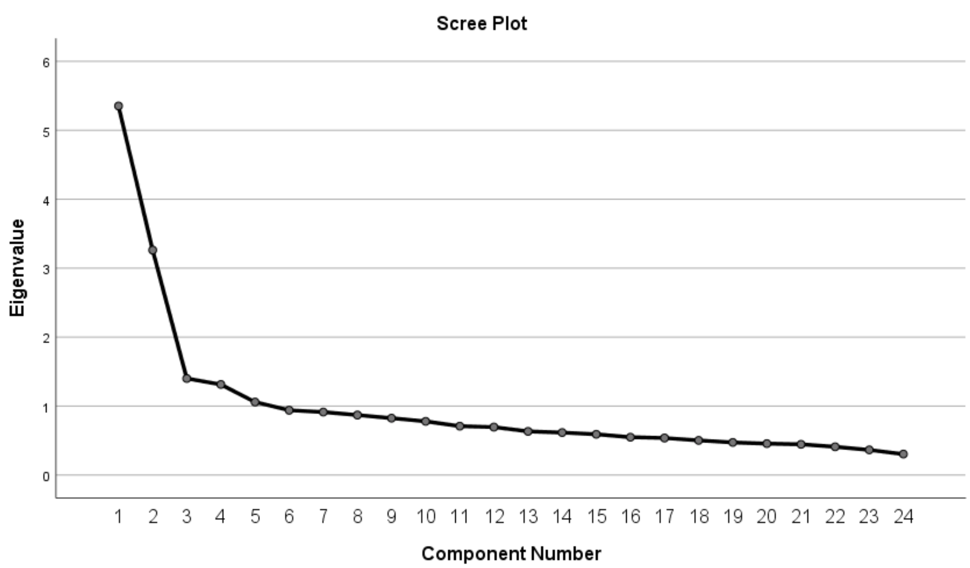

Figure 4. Scree plot of 24-item HS-STEBI-bio.

Table 4

First Trial Corrected Item – Total Scale Correlations and Component Loadings

	Measure	Positive-Negative	Corrected Item-Total Correlation	Component Loadings 1	2
Personal Efficacy in Teaching Biology	Item 2	P	0.37	0.42	0.28
	Item 3	N	0.47	0.57	0.03
	Item 5	P	0.59	0.70	0.15
	Item 6	P	0.49	0.56	0.15
	Item 8	P	0.62	0.75	0.13
	Item 12	P	0.51	0.65	-0.00
	Item 17	P	0.40	0.46	0.23
	Item 18	P	0.45	0.57	-0.05
	Item 19	N	0.52	0.66	-0.17
	Item 21	N	0.32	0.38	0.05
	Item 22	N	0.54	0.62	0.03
	Item 23	P	0.41	0.52	0.02
	Item 24	N	0.51	0.57	0.22
Total Scale Alpha = .81					
Outcome Expectancy in Teaching Biology	Item 1	P	0.47	0.06	0.61
	Item 4	P	0.55	0.13	0.67
	Item 7	P	0.48	-0.12	0.62
	Item 9	P	0.47	0.14	0.57
	Item 10	N	0.27	-0.04	0.32
	Item 11	P	0.52	0.11	0.65
	*Item 13	N	0.27	0.25	0.30
	Item 14	P	0.47	0.03	0.59
	Item 15	P	0.58	0.04	0.68
	Item 16	P	0.42	0.18	0.53
	Item 20	P	0.56	0.19	0.65
	Item 25	N	0.39	0.04	0.47
Total Scale Alpha = .80					

* Item removed due to cross loading

Item 13 was deleted and Principal Component Analysis with varimax orthogonal rotation was repeated on 24 items. The eigenvalues dropped to 5.35 and 3.26 for first and second principal components, respectively, but the total variance explained slightly increased, 22.30 and 13.59 for first and second components, respectfully. The scree plot in Figure 4 showed inflexion that two principal components could be retained. Again, 13 variables (2, 3, 5, 6, 8, 12, 17, 18, 19, 21, 22, 23, and 24) loaded into the first principal components while 11 variables (1, 4, 7, 9, 10, 11, 14, 15, 16, 20, and 25) defined the second principal component. The loadings were in consensus with the results obtained by (Rubeck, 1990) except that item 13 was deleted from the second components. All the loadings reached .3, the lowest criteria for retaining a variable to define a component. The results of component loadings of the PCA are displayed in Table 5.

Reliability Test

The internal consistency reliability of both Personal Efficacy in Teaching Biology (PETB) and Outcome Expectancy in Teaching Biology (OETB) subscales was repeated using Cronbach's alpha. The PETB subscale recorded overall alpha of .81. Again, the 13 items reached Corrected Item-Total Correlation of .3 and above. The total reliability of OETB subscales, .80. Each variable reached a Corrected Item-Total Correlation of .3 and except item 10. Item 10 was deleted from further analysis. The Item-Total Correlation and overall reliability test results are displayed in Table 5.

Item 10 was deleted and PCA with varimax orthogonal rotation was repeated on 24 items. The eigenvalues indicated a slight reduction, 5.33 and 3.21 but the total variance explained increased to 23.18 and 14.00 for first and second components respectfully. The scree plot in Figure 5 showed inflexion that two principal components could be retained. Again, 13 variables (2, 3, 5, 6, 8, 12, 17, 18, 19, 21, 22, 23, and 24) loaded into the first principal components while 10 variables (1, 4, 7, 9, 11, 14, 15, 16, 20, and 25) defined the second principal component. The loadings were consistent with the results obtained by (Rubeck, 1990) except that items 10 and 13 were deleted from the second component. All the loadings reached .3, the lowest criteria for retaining a variable to define a component. Table 6 displays the component loadings of the PCA.

The internal consistency reliability of both Personal Efficacy in Teaching Biology (PETB) and Outcome Expectancy in Teaching Biology (OETB) subscales was repeated using Cronbach's alpha. The PETB subscale recorded overall alpha of .81. Again, the 13 items reached Corrected Item-Total Correlation of .3 and above. The total reliability of OETB increased to .81, and each variable reached a Corrected Item-Total Correlation of .3. Table 6 displays the results of Item-Total Correlation and overall reliability test. Table 7 shows descriptive statistics of items in HS-STEBI- bio.

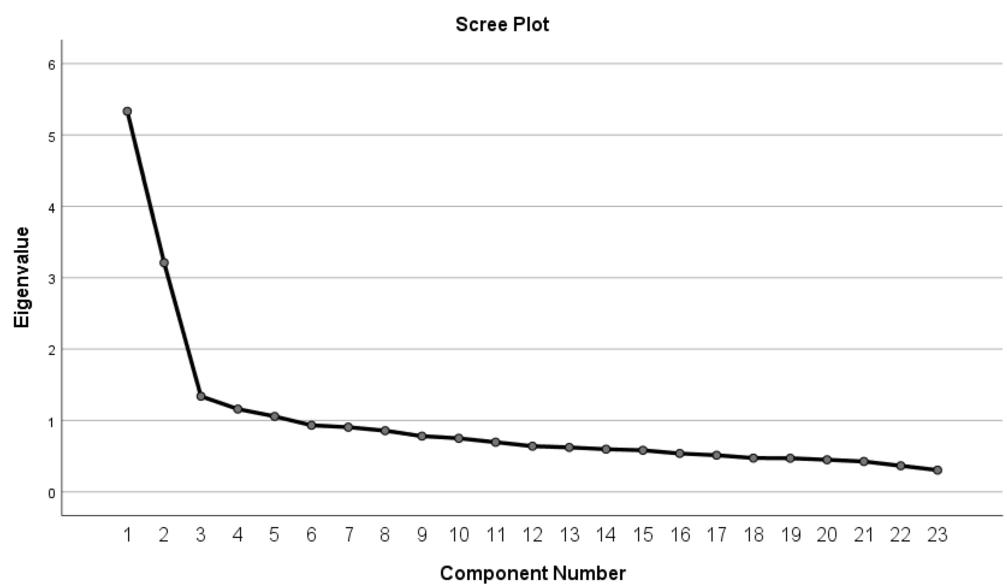

Figure 5. Scree plot of 23-item HS-STEBI-bio.

Table 5

Second Trial Corrected Item–Total Scale Correlations and Component Loadings

	Measure	Positive-Negative	Corrected Item-Total Correlation	Component Loadings	
				1	2
Personal Efficacy in Biology Teaching	Item 2	P	0.37	0.41	0.27
	Item 3	N	0.47	0.57	0.02
	Item 5	P	0.59	0.71	0.14
	Item 6	P	0.49	0.57	0.15
	Item 8	P	0.62	0.75	0.13
	Item 12	P	0.51	0.65	-0.00
	Item 17	P	0.40	0.47	0.23
	Item 18	P	0.45	0.57	-0.05
	Item 19	N	0.52	0.66	-0.18
	Item 21	N	0.32	0.38	0.04
	Item 22	N	0.54	0.62	0.02
	Item 23	P	0.41	0.52	0.02
	Item 24	N	0.510	0.57	0.21
Total Scale Alpha = .81					
Outcome Expectancy in Biology Teaching	Item 1	P	0.48	0.06	0.62
	Item 4	P	0.55	0.13	0.68
	Item 7	P	0.50	-0.12	0.62
	Item 9	P	0.46	0.14	0.56
	*Item 10	N	0.26	-0.05	0.31
	Item 11	P	0.52	0.12	0.65
	Item 14	P	0.48	0.04	0.60
	Item 15	P	0.59	0.04	0.69
	Item 16	P	0.42	0.19	0.53
	Item 20	P	0.55	0.20	0.65
	Item 25	N	0.38	0.04	0.46
Total Scale Alpha = .80					

* Item removed due to low corrected item-total correlation and borderline loading

Table 6

Final Corrected Item–Total Scale Correlations and Component Loadings

	Measure	Positive-Negative	Corrected Item-Total Correlation	Component Loadings 1	2
Personal Efficacy in Teaching Biology	Item 2	P	0.37	0.40	0.28
	Item 3	N	0.47	0.58	0.02
	Item 5	P	0.59	0.70	0.16
	Item 6	P	0.49	0.56	0.17
	Item 8	P	0.62	0.74	0.15
	Item 12	P	0.51	0.65	0.01
	Item 17	P	0.40	0.46	0.24
	Item 18	P	0.45	0.57	-0.03
	Item 19	N	0.52	0.67	-0.17
	Item 21	N	0.32	0.38	0.03
	Item 22	N	0.54	0.62	0.04
	Item 23	P	0.41	0.52	0.03
	Item 24	N	0.51	0.57	0.22
Total Scale Alpha = .81					
Outcome Expectancy in Teaching Biology	Item 1	P	0.49	0.05	0.62
	Item 4	P	0.56	0.12	0.68
	Item 7	P	0.48	-0.13	0.61
	Item 9	P	0.47	0.13	0.57
	Item 11	P	0.56	0.10	0.67
	Item 14	P	0.50	0.024	0.60
	Item 15	P	0.58	0.03	0.68
	Item 16	P	0.44	0.17	0.55
	Item 20	P	0.56	0.18	0.66
	Item 25	N	0.33	0.040	0.44
Total Scale Alpha = .81					

* Item removed due to low corrected item-total correlation

Table 7

Descriptive Statistics of Items HS-STEBI-bio

	N	Mean	SD
Item 1. When a student does better than usual in biology, it is often because the teacher exerted a little extra effort.	552	2.25	0.92
Item 2. I continuously find better ways to teach biology.	552	1.40	0.57
* Item 3. Even if I try very hard, I do not teach biology as well as I teach other science subjects.	552	1.69	1.01
Item 4. When the biology grades of students improve, it is often due to their teacher having found a more effective teaching approach.	552	2.17	0.84
Item 5. I am able to teach biology concepts effectively.	552	1.42	0.65
Item 6. I am effective in monitoring hands-on biology activities.	552	1.46	0.61
Item 7. If students are underachieving in biology, it is most likely due to ineffective teaching.	552	3.34	1.12
Item 8. I generally teach biology concepts effectively.	552	1.45	0.60
Item 9. The inadequacy of a student's background in the science of biology can be overcome by good teaching.	552	2.11	0.88
Item 10. The low science achievement of some students in biology cannot be blamed on their teachers.	552	2.47	1.12
Item 12. I understand biology concepts well enough to be an effective high school biology teacher.	547	1.17	0.44
Item 14. The teacher is generally responsible for the achievement of students in biology knowledge of biology content.	547	2.30	0.99
Item 15. Students' achievement in biology is directly related to their teachers' effectiveness.	547	2.39	0.96
Item 16. If parents comment that their child is showing more interest in biology at school, it is probably due to the performance of the child's teacher.	547	2.10	0.82
Item 17. I find it easy to use hands-on activities such as experiments and demonstrations to explain biology concepts to students.	546	1.78	0.95
Item 18. I am able to answer students' biology questions.	547	1.28	0.63
* Item 19r Bio 19. I wonder if I have the necessary skills to teach biology.	547	1.61	1.02
Item 20. Effective biology teachers influence low-motivated students' achievement.	547	1.99	0.80
* Item 21. Given a choice, I would not invite my principal to evaluate my biology teaching.	547	1.76	1.16
* Item 22. When a student has difficulty understanding a biology concept, I am usually at a loss as to how to help the student understand it better.	547	1.53	0.79
Bio 23. When teaching biology, I usually welcome students' questions.	547	1.16	0.47
* Item 24. I do not know what to do to turn students on to biology.	547	1.99	0.99
* Item 25. Even teachers with good teaching abilities cannot help some students to learn biology.	547	3.35	1.22

Note: Item 10 and item 13 were deleted. * Item reverse-scored.

Summary

With items 10 and 13 dropped from the PCA and reliability tests, 23 items constituted HS-STEBI-bio and made the instrument slightly different from STEBI-chem that was defined by 25 items. Nonetheless, the variables that defined the first and second components were consistent with that which constituted the first and second factors in the original scales. Additionally, the reliability coefficient of the subscales in HS-STEBI-bio was consistent with the reliability of the subscales in existing STEBI. Apart from the reduction in the number of variables, the results obtained from PCA and reliability tests seemed to indicate that STEBI-bio is a valid and reliable instrument to measure teacher efficacy beliefs about biology teaching. It appears to mean that modification of the scale and administration to high school biology teachers, a population different from elementary teachers for which the original STEBI was developed for, did not alter the consistency of the instrument.

Confirmatory Factor Analysis

A Confirmatory Factor Analysis (CFA) is an ideal test for assessing the validity of an existing instrument such as STEBI or STEBI-chem. A CFA test failure in the pilot study was attributed to a small sample size (N = 46). In the current study, the sample size was larger, with no missing values, N = 527. Thus, a CFA was conducted to support the validity of STEBI-bio as an instrument with two principal components. First, a dataset with cases with no missing values was prepared. A box plot was used to identify outliers and the cases with outliers were deleted. Then, the negative items were reverse-scored. Using *SPSS* AMOS, a CFA was performed on the 25-item HS-STEBI-bio (13 PETB and 12 OETB). Table 8 shows the pattern coefficient and *p*-value associated with each weight. In addition, Figure 6 shows path diagram of the STEBI-bio model. All of the estimated coefficients reached statistical significance, $p < .001$, indicating the 13 variables are significant indicators of Personal Efficacy in Teaching Biology teaching, and 12 items are significant measures of

Outcome Expectancy in Teaching Biology. However, items 10, 13, and 21 failed to reach .3 coefficient.

Then model fit was determined with four indexes, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Normal Fit Index (NFI), and Goodness of Fit Index (GF1). The results showed, RMSEA = .07, CFI = .78, NFI = .73, and GFI = .85. The NCI and CFI were less than .95, a baseline for a good model fit (Meyers, Gamst & Guarino, 2006, p. 873). Items 10, 13 and 21 were removed one at a time and model fit indexes were re-calculated each time. All regression weights reached .3 and above, but the indexes did not improve to reach the acceptable baseline for a good model fit, RMSEA = .08, CFI = .82, NFI = .77, and GFI =.87. The analysis was discontinued since the purpose of the study was not exploratory. Figure 7 shows the path diagram and pattern coefficient of the STEBI-bio model. The path diagram also indicated a low but positive and significant relationship between PETB and OETB, $r = .37$, $p < .001$, suggesting the two subscales are related but strong to measure similar subconstruct.

Table 8

Regression Weight and Significance Level

	Indicator	Regression Weight
Personal Efficacy in Teaching Biology	Item 2	0.46***
	Item 3	0.44***
	Item 5	0.74***
	Item 6	061***
	Item 8	0.80***
	Item 12	0.61***
	Item 17	0.46***
	Item 18	0.52***
	Item 19	0.50***
	Item 21	0.28***
	Item 22	0.49***
	Item 23	0.52***
	Item 24	0.49***
Outcome Expectancy in Teaching Biology	Item 1	0.57***
	Item 4	0.64***
	Item 7	0.50***
	Item 9	0.53***
	Item 10	0.18***
	Item 11	0.66***
	Item 13	0.26***
	Item 14	0.56***
	Item 15	0.65***
	Item 16	0.57***
	Item 20	0.62***
	Item 25	0.33***

*** $p<.001$

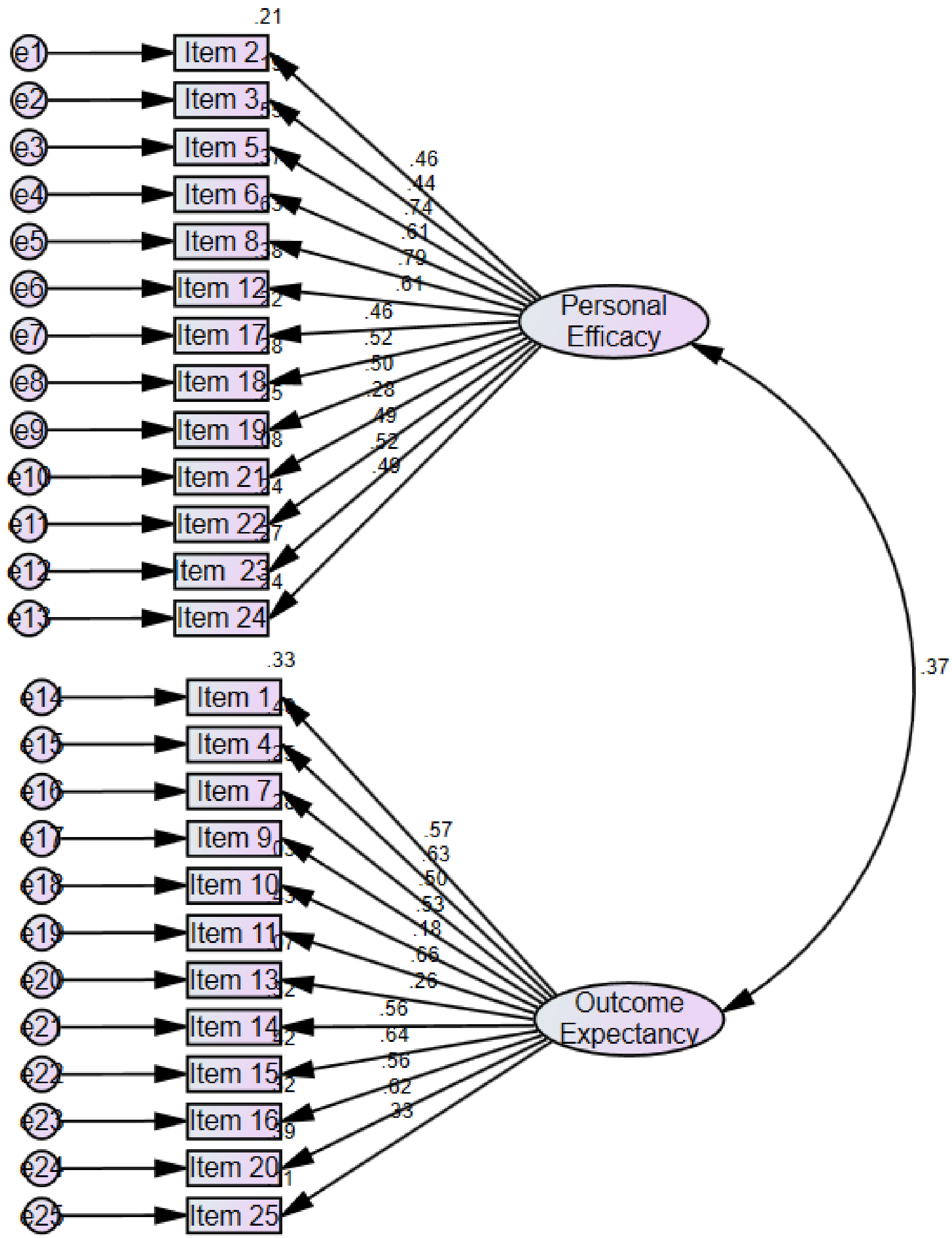

Figure 6. Path diagram HS-STEBI-bio model with 25 indicators.

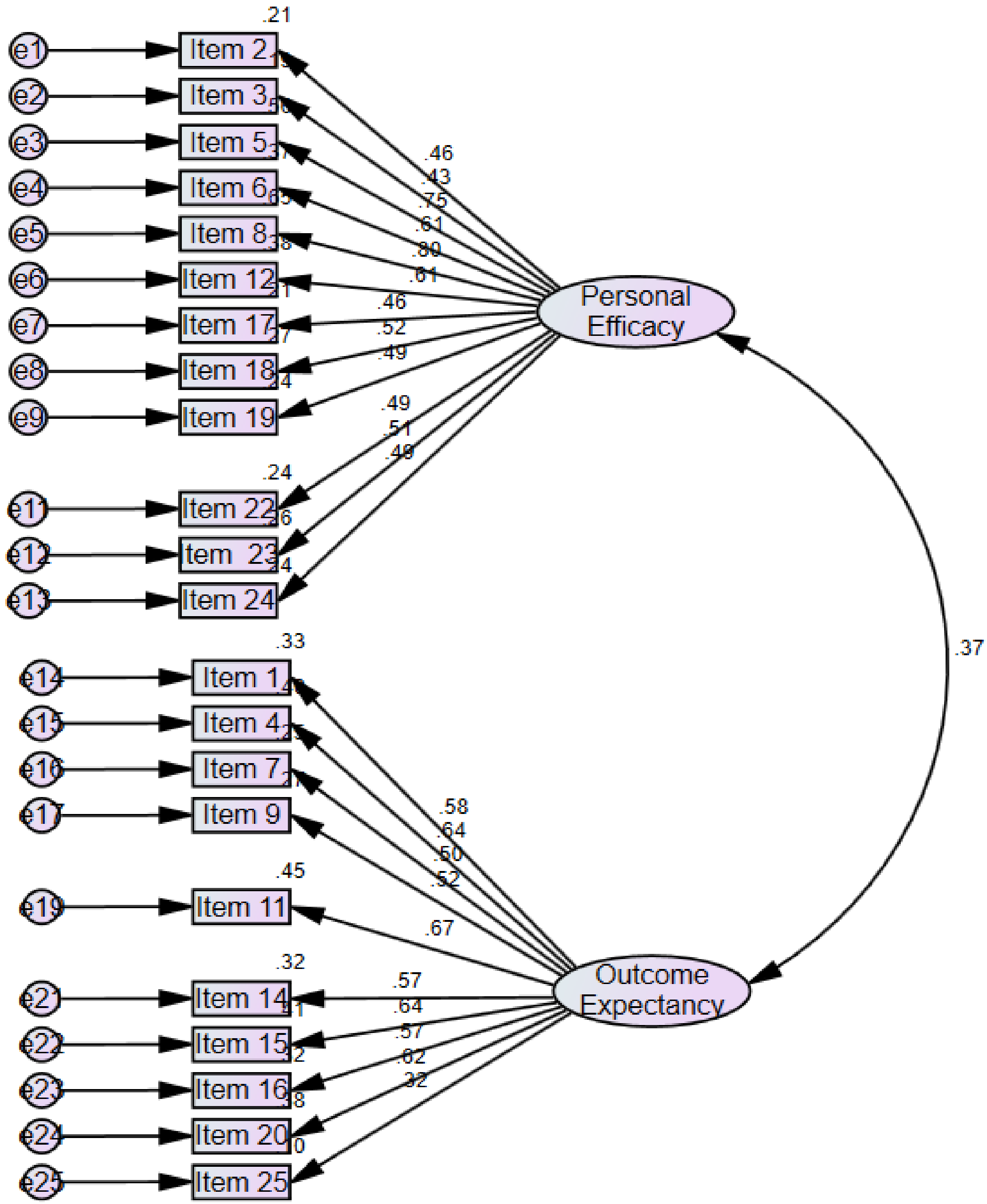

Figure 7. Path diagram HS-STEBI-bio model with 22 indicators.

Pearson Correlation

Before using the subscale to measure different subconstructs, personal efficacy and outcome expectancy, a Pearson correlation analysis was conducted to determine the correlation coefficient of Personal Efficacy in Teaching Biology and Outcome Expectancy in Teaching Biology. The results showed that the two subscales have low but positive and significant correlation, $r = .24$, $p < .001$. The results supported that each subscale could be used to measure similar but different subconstructs.

Dummy Coding Categorical Variables

The predictors, certification, undergraduate degree major, and teaching experience are all categorical variables. Consequently, they were dummy coded before multiple regression analysis as displayed in Table 9. Within the certification category, composite science certification was chosen as a baseline comparison because this study aimed to compare composite science with subject-specific (life science and biology) certification. The "other" type of certification was dropped due to the very few numbers of participants in the category. To compare the efficacy beliefs of the teachers with a different undergraduate degree, the "other" type of undergraduate degree major was the reference because Goldhaber and Brewer (2000) reported that having a degree in science had no impact on teacher effectiveness. Thus, this study aimed to compare efficacy beliefs of the teachers with an undergraduate degree in science with non-science degree fields. Studies reported differing viewpoints on the influence of teaching experience on teacher effectiveness. However, the viewpoints leaned toward older teachers being more effective than teachers who had fewer years of experience in the profession. Thus, the most experienced teachers, the veterans, were chosen as the baseline comparison with novice and intermediate teachers.

Table 9

Dummy Code Certification and Teaching Experience

	Life science	Biology
Life Science	1	0
Biology	0	1
Composite Science	0	0

	0 to 5 years	6 to 10 years
0 to 5 years	1	0
6 to 10 years	0	1
11 years Plus	0	0

Regression Analysis

First, the 13 variables that measure PETB were summed to obtain a composite score. Similarly, the composite score of the 10 variables that define OETB was obtained. To assess the independent effect of composite science certification and subject-specific certification (life science and biology), a hierarchical multiple regression analysis was conducted using composite science as the reference group. Included in the regression analysis was teaching experience, 0 to 5 years and 6 to 10 years, with more than 10 years as the baseline comparison. Additionally, the biological science undergraduate major was entered into the model as the control with "other" undergraduate major (not biological science or physical science) as the reference group.

With alpha equal to .05, a two-stage hierarchical multiple-regression analysis was used to predict Personal Efficacy in Teaching Biology. In the first block, 0 to 5 years teaching experience, 6 to 10 years teaching experience, and biological science undergraduate major were entered simultaneously as covariates. In the second block, biology certification and life certification were entered simultaneously as primary variables of interest. The correlations of the variables are shown in Table 10. As can be seen, biology certification and life science certification recorded negative and statistically significant correlation, $r = -.40$, $p < .001$. Table 11 shows the descriptive statistics of the variables in the regression model.

The results of the hierarchical multiple regression analysis are shown in Table 12. The three control variables, 0 to 5 years, 6 to 10 years, and biological science undergraduate major entered in the first block are statistically significant predictors of Personal Efficacy in Teaching Biology, $F(3, 508) = 11.49$, $p < .001$, $R^2 = .06$. The results showed teaching experience 0 to 5 years, $\beta = .28$, $p < .000$, and teaching experience 6 to 10 years, $\beta = .145$, $p = .002$, to predict higher levels of Personal Efficacy in Teaching Biology than teaching experience of more than 10 years. Though not statistically significant, a biological science undergraduate degree major predicted higher level of Personal Efficacy in Teaching Biology than “other” major (not biological or physical science).

When the predictors of interest, life science and biology certifications were entered simultaneously in the second block, the covariates, teaching experience (0 to 5 years and 6 to 10 years) remained positive and statistically significant predictors. However, life science and biology certification did not make significant contribution to the model, $F(2, 506) = .05$, $p > .05$, $\Delta R^2 = .00$. Thus, composite science certification and subject-specific certification (life science and biology) were non-significant predictors of Personal Efficacy in Teaching Biology. The covariates, teaching experience 0 to 5 and 6 to 10 were significant predictors of Personal Efficacy in Teaching Biology.

Again, at alpha equal to .05, a two-stage hierarchical multiple regression analysis was used to predict Outcome Expectancy in Teaching Biology. In the first block, 0 to 5 years teaching experience, 6 to 10 years teaching experience, and biological science undergraduate major were entered simultaneously as control variables, and in the second block biology certification and life science certification were entered simultaneously as primary variables of interest. In the first block, the three control variables, 0 to 5 years, 6 to 10 years, and biological science undergraduate major were nonsignificant predictors of Outcome Expectancy in Teaching Biology, $F(3, 509) = 1.459$, $p > .05$, $R^2 = .01$. Similarly, in the second block, biology and life science certifications were non-significant predictors of Outcome Expectancy in Teaching Biology, $F(2, 507) = .39$, $p > .05$, $R^2 = .01$. The overall model did not improve significantly in its predictive power when biology and life science certification were entered into the model, $F(5, 1.03) = .39$, $p > .05$, $R^2 = .01$. Therefore, composite science certification and subject-specific certification (life science and biology) were non-significant predictors of Outcome Expectancy in Teaching Biology.

Table 10

Correlation Coefficient of Variables in Regression Model

	1	**2**	**3**	**4**	**5**	**6**
Personal Efficacy						
1. Personal Efficacy in Teaching Biology	_					
2. Experience 0 to 5 Years	.22***	_				
3. Experience 6 to 10 Years	.03	-.42***	_			
4. Biological Science Undergraduate Major	.00	-.05	.05	_		
5. Life Science Certification	.01	-.06	.12**	-.06	_	
6. Biology Certification	-.10**	-.27***	-.08*	.07	-.40***	_
Outcome Expectancy						
1. Outcome Expectancy in Teaching Biology	_					
2. Experience 0 to 5 Years	-.05	_				
3. Experience 6 to 10 Years	.07	-.42***	_			
4. Biological Science Undergraduate Major	.06	-.05	.05	_		
5. Life Science Certification	.00	-.06	.12**	-.06	_	
6. Biology Certification	.04	-.27***	-.08*	.07	-.40***	_

Note. ****p* < .001. ***p* < .01. **p* < .05.

Table 11

Descriptive Statistics of Variables in Regression Model

	Mean	SD
Personal Efficacy		
Personal Efficacy in Teaching Biology	19.41	5.50
Experience 0 to 5 Years	.38	.49
Experience 6 to 10 Years	.23	.42
Biological Science Undergraduate Major	.77	.42
Life Science Certification	.43	.50
Biology Certification	.17	.38
Outcome Expectancy		
Outcome Expectancy in Teaching Biology	23.92	5.63
Experience 0 to 5 Years	.38	.49
Experience 6 to 10 Years	.22	.42
Biological Science Undergraduate Major	.77	.42
Life Science Certification	.43	.50
Biology Certification	.17	.38

Table 12

Hierarchical Multiple Regression Analysis

Predictor	Personal Efficacy		Outcome Expectancy	
	ΔR^2	β	ΔR^2	β
Step 1(Covariates)	.06***		.01	
Experience 0 to 5 Years		.28***		-.02
Experience 6 to 10 Years		.15**		.06
Biological Science Major		.01		.06
Step 2(Certification)	.00		.00	
Life Science Certification		.00		.02
Biology Certification		-.01		.05
Total R^2	.06		.01	

Note. Step two included predictors from step one. ***$p < .001$. **$p < .01$

Chapter V

Conclusion, Interpretation, and Implications

The purpose of this study was to examine the validity and reliability of a modified Teacher Efficacy Belief Instrument and to compare personal efficacy and outcome expectancy of biology teachers certified in composite science with others certified by a more concentrated subject-specific test. There was no known existing instrument with which to specifically assess personal efficacy and outcome expectancy of high school science subject teachers. Thus, a STEBI-chem used in middle grades was adapted to obtain HS-STEBI-bio. The study was guided by the research question: Does a significant difference in personal efficacy or outcome expectancy exist between biology teachers certified in composite science with biology teachers certified in more subject-specific science certification field controlling for undergraduate degree major and teaching experience?

Review of Methodology

Qualtrics distributed HS-STEBI-phys, HS-STEBI-bio, HSTEBI-chem, and demographic questions online simultaneously through the same link to physics, biology, and chemistry in-service teachers in Texas public high schools. Data were imported into IBM SPSS statistics for analysis. However, HS-STEBI-bio data only were analyzed in this study. A Principal Component Analysis (PCA) was conducted to study the validly of HS-STEBI-bio followed by a Confirmatory Factor Analysis using *SPSS* AMOS statistics. The reliability of the subscales in the instrument was determined using Cronbach's Alpha. Then, a hierarchical multiple regression was used to compare personal efficacy and outcome expectancy of composite teachers and of subject-specific teachers while controlling for effects of teaching experience and undergraduate college major.

Conclusion

The descriptive statistics revealed a majority of the participants obtained certification in composite science, a finding supported by Ramsay (2013, 2015, 2016) who reported that science teacher candidates prefer composite science certification. However, generally, the results from hierarchical multiple regression analysis revealed that certification showed no significant effect on personal efficacy or outcome expectancy of the biology teachers. The present findings support previous findings (Croninger, Rice, Rathbun, & Nishio, 2007; Goldhaber & Brewer, 2000; Kane, Rockoff, & Staiger, 2008, Wiseman & Al-bakr, 2013) documenting that certification does not influence teacher effectiveness. Rather, the control variable, an undergraduate major in a teaching subject (biological science), predicted a higher level of personal efficacy and outcome expectancy than undergraduate major in a different field, non-science majors. Again, this finding supported previous research (Croninger, Rice, Rathbun, & Nishio, 2007; Darling-Hammond, 2000; Evans, 2011; Darling-Hammond, 2000; Ingersoll, 2003) on the importance of teachers obtaining subject-specific degrees.

The results of Principal Component Analysis (PCA) supported the validity of HS-STEBI-bio. The results showed loadings in personal efficacy subscale were consistent with Riggs and Enochs (1990); Rubeck (1990). However, HS-STEBI-bio is not entirely congruent with existing instruments. Deletion of two items from outcome expectancy subscales reduced the number of items in the HS-STEBI-bio to 23 (13 personal efficacy and 10 outcome expectancy). The original STEBI and STEBI-chem each contains 25 items (13 personal efficacy and 12 outcome expectancy). It is important to mention that the results of Confirmatory Factor Analysis failed to support the validity of HS-STEBI-bio, an indication that the scale may not be valid in a high school science context, specifically with biology teachers. But, based on the results of PCA, the HS-STEBI-bio could be considered valid since Riggs and Enochs (1990) used factor analysis to develop the original instrument, an analysis similar to PCA. The results of the PCA supported the importance of studying validity and reliability of existing teacher efficacy beliefs instrument (Tschannen-Moran & Hoy, 2001).

The reliability coefficient of the subscales in HS-STEBI-bio was good and consistent with that obtained in the existing scales. Overall, results obtained from PCA and reliability tests seemed to indicate that HS-STEBI-bio is a valid and reliable measure of teacher efficacy beliefs in a high school science context. The findings suggested that modification of an existing STEBI-chem and administration to a different population did not change much of the validity or the internal consistency of the instrument. Apart from two items that were dropped, the validity and reliability test results were consistent with STEBI-chem that was administered to science teachers in middle grade and to STEBI used with elementary grade teachers. Hence, context and subject matter differences seemed to minimally influence the validity and reliability of the emerging scale.

Contrary to expectations, the results of hierarchical multiple regression showed covariates were the significant predictors and not the primary predictors of interest, that is, certification. When Kane, Rockoff, and Staiger (2008) observed that math and reading scores of elementary and middle-grade students taught by certified and uncertified teachers were similar, Kane, Rockoff, and Staiger recommended to educational policymakers to seek alternative ways of screening out less qualified teachers other than by certification processes. Since the subject-area undergraduate major shows a positive relationship with both personal efficacy and outcome expectancy, a suggestion is for policymakers to consider requiring biology teachers to obtain a major or at least a minor in biology. The policymakers could also revert to having composite teachers obtain at least a minor in all five teaching subjects, a practice that was in place in Texas before certification by examination.

Certification only did not make a significant contribution to the prediction model, thus suggesting variables other than certification could influence the ability of the teachers to teach biology effectively to the students and their belief that effective instruction will lead to students' learning gains. Biology certification and an undergraduate degree in biological science were positively correlated, but the relationship was nonsignificant, $r = .07$, $p > .05$, to assess the influence of a combination of certification and a major in a teaching subject on teacher efficacy beliefs. Nonetheless, Darling-Hammond (2000) reported that having both certification and a major in a teaching subject were consistent and positive significant predictors of student achievement. A suggestion would have been to explore the influence of having both a college major in biological science and biology certification in personal efficacy of the biology teachers. However, biology certification was discontinued.

Teaching experience covariates recorded unexpected results. The novice and intermediate teachers significantly predicted a higher level of Personal Efficacy in Teaching biology than veteran teachers. According to Darling-Hammond (2000), new teachers are the strongest consistent negative predictors of student achievement, and the report was supported by the work of Clotfelter, Ladd, and Vigdor (2007). However, empirical studies have a different grouping for new teachers. In the study by Luft, Firestone, Wong, Ortega, Adams, and Bang (2011), the beginning teachers had zero to two years teaching experience; while in the Child and McNicholl (2007) study, the novice teachers had 0 to 5 years teaching experience. Thus, the grouping of teaching experience used in this study could influence the study outcome. Clotfelter, Ladd, and Vigdor (2007) also mentioned that the benefit of having experience on teacher effectiveness do not always follow a diagonal line. Some of the reasons for nonlinear relationships were teacher attrition, non-effective teachers left behind, and veteran teachers who did not continuously engage in learning opportunities while on the job.

Implication

The instrument adapted for this study could be used to investigate teacher efficacy beliefs of subject teachers in secondary schools including non-science subjects. Consequently, this study could be the first time the STEBI is modified for studies in the high school context. Additionally, this study supported the importance of re-assessing the psychometric properties of a modified Science Teaching Efficacy Instrument. Specifically, the outcome expectancy subscale was reduced from 12 in the original scale to 10 items in this study due to cross loading and item-total correlation with other variables in reliability analysis. Thus, the HS-STEBI-bio is a 23-item scale while the existing scales, STEBI-chem and STEBI, are each a 25-item instrument.

With the confounding variables in the regression model, the composite and subject-specific certification did not affect teacher efficacy beliefs. Thus, certification only could not be used as a measure of teacher effectiveness of the biology teachers. Rather, the teacher efficacy beliefs were significantly predicted by the control variables, teaching experience (0 to 5 years and 6 to 10 years) implying variables other than certification are responsible for teacher efficacy beliefs. These variables could not have been examined in this study because the regression model accounted for less than ten percent of the variance in teachers' efficacy beliefs. In addition, more than 90 percent of the variance was still unexplained.

The trend observed in this study is that a majority of the biology teachers earned certification in composite science only or composite science with other types of secondary science certification. A composite science certificate qualifies a teacher to teach not only biology but also most other high school courses. Since composite science is a preferred field for most secondary biology teachers, it will be important to conduct a follow-up study with interviews and observations on the effectiveness of generalist teachers. One way is to review the performance of students' scores in the STAAR biology end-of-course exam and to compare the performance of students taught by composite teachers with the performance of students taught by subject-specific teachers.

Additionally, the results revealed that a majority of biology teachers acquired various certifications in science, thereby signaling that in-service biology teachers earned additional certifications while teaching and that composite science is dominant. Initial screening for the standard license could include an assessment of the number of credits that candidates earned in science. However, a subsequent requirement for "adding additional certification" seems not to include credit hours obtained in a science field. Thus, classroom teachers who obtained composite science as an additional certificate may not have a minor or major in science. According to Darling-Hammond (2000), the strongest and consistently negative predictors of student achievement is the lack of at least a minor in a teaching subject. Darling-Hammond (2000) maintained that a combination of certification and a major in a teaching subject are consistent positive predictors of student outcome. Though not statistically significant, the results of hierarchal regression analysis showed that an undergraduate major in biological science predicted higher levels of both personal efficacy and outcome expectancy in teaching biology than an undergraduate major in a non-physical science or non-biological science.

Based on empirical evidence and the results of this investigation, policymakers should re-examine the practice of "adding additional certification by examination." There is a demonstrable benefit of possessing an undergraduate major in a teaching subject. Instead of just taking a test, classroom teachers should be required to earn a minor in each of the teaching fields covered by composite science (biology, chemistry, physics, earth, and space science).

Moreover, since the majority of science teachers prefer certification in composite science, a certificate that qualifies teachers to teach most science subjects, a subject-specific certification could gradually be extinguished. Thus, is it necessary to continue to conduct empirical studies on the effectiveness of general-science certified teachers?

Limitation

Some teachers earned more than one type of certification including composite science and subject-specific certification. Thus, teachers earning multiple certifications make it difficult to distinctly study the effect of composite and subject-specific certification on efficacy beliefs of biology teachers. Moreover, the results of Confirmatory Factor Analysis showed that data did not fit the model, an indication that the HS-STEBI-bio may not be a valid scale for this study.

Besides, what teachers believe may be different from what teachers practice in the classrooms. Instructional differences between individual teachers are essential measures of teacher effectiveness. However, this study did not include classroom observation of teaching behaviors of the participants. Thus, a qualitative study such as interviews and observations will support the results of the current research and will probably be most effective in capturing teacher efficacy beliefs.

Additionally, students' learning seems the most important measure of effective teaching, but a comparison of the efficacy of composite science and subject-specific certified science teachers in improving students' learning gains is beyond the scope of this study. Only a proxy measure of teacher effectiveness, such as teacher efficacy beliefs, was employed in the study. Direct matching of student performance in composite teachers' classroom and subject-specific teachers' class seems an adequate measure of the effectiveness of the certified teachers. Since biology is one of the required state tests for high school graduation, a quantitative study to compare the performance of students taught by composite teachers with student taught by subject-area teachers (life science or biology) will compensate the limitations of the current study.

By their nature, survey methodologies produce subjective data. The validity of the results is therefore dependent on the participants providing honest and accurate responses. Besides, the majority of participants were White, and thus, results of this investigation may not generalize to minority teachers of biology. Besides, only the researcher did the coding. That may have introduced errors in the study. Finally, the participants in each certification group (composite, life science, or biology), were treated as having taken similar certification tests.

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Appendix A

Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990)

Science Teaching Efficacy Belief Instrument
Please indicate the degree to which you agree or disagree with each statement below by checking appropriate box 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 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
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 am not 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 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 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 find it difficult to explain to students why science experiments work.	SA A UN D SD

18. I am typically able to answer students' science questions.	SA A UN D SD
19. I wonder if I have the necessary skills to teach science.	SA A UN D SD
20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.	SA A UN D SD
21. Given a choice, I would not invite the principal to evaluate my science teaching.	SA A UN D SD
22. When a student has difficulty understanding a science concept, I as usually at a loss as to how to help the student understands it better.	SA A UN D SD
23. When teaching science, I usually welcome student questions.	SA A UN D SD
24. I do not know what to do to turn students on to science.	SA A UN D SD
25. Even teachers with good science teaching abilities cannot help some kids to learn science.	SA A UN D SD

Appendix B

Science Teaching Efficacy Belief Instrument-chem

Science Teaching Efficacy Belief Instrument-chem
Please indicate the degree to which you agree or disagree with each statement below by checking appropriate box to the right of each statement. SA = STRONGLY AGREE A = AGREE UN = UNCERTAIN D = DISAGREE SD = STRONGLY DISAGREE

1. When a student does better in the chemistry section of science, it is often because the teacher exerted a little extra effort. SA A UN D SD
2. I am continually finding better ways to teach chemistry. SA A UN D SD
3. Even when I try very hard, I do not teach chemistry as well as I do most areas of science. SA A UN D SD
4. When students' grades in the chemistry section of science 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 chemistry concepts effectively. SA A UN D SD
6. I am not very effective in monitoring chemistry experiments. SA A UN D SD
7. If students are underachieving in the chemistry section of Science, it is most likely due to ineffective chemistry teaching. SA A UN D SD
8. I generally teach the chemistry section of science ineffectively. SA A UN D SD
9. The inadequacy of a student's background in chemistry can overcome by good teaching. SA A UN D SD
10. The low science achievement of some students in the chemistry section of science cannot be blamed on their teachers. SA A UN D SD
11. When a low-achieving child progresses in the chemistry section of science, it is usually due to extra attention given by the teacher. SA A UN D SD
12. I understand chemistry concepts well enough to be effective in teaching middle school chemistry. SA A UN D SD
13. Increased effort in chemistry teaching produces little change in some students' chemistry achievement. SA A UN D SD
14. The teacher is generally responsible for the achievement of students in the chemistry section of science. SA A UN D SD
15. Students' achievement in the chemistry section of science is directly related to their teachers' effectiveness in teaching. SA A UN D SD

16. If parents comment that their child is showing more interest in the chemistry section of science at school, it is probably due to the performance of the child's teacher. SA A UN D SD
17. I find it difficult to explain to students why chemistry experiments work. SA A UN D SD
18. I am typically able to answer students' chemistry questions. SA A UN D SD
19. I wonder if I have the necessary skills to teach the chemistry section of science. A A UN D SD
20. Effectiveness in chemistry teaching has little influence on the achievement of students with low motivation. SA A UN D SD
21. Given the choice I would not invite the principal to evaluate my science teaching in chemistry. SA A UN D SD
22. When a student has difficulty understanding a chemistry concept, I am usually at a loss as to how to help the student understand it better. SA A UN D SD
23. When teaching chemistry, I usually welcome student questions. SA A UN D SD
24. I do not know what to do to turn students on to chemistry. SA A UN D SD
25. Even teachers with good teaching abilities cannot help some kids to learn chemistry SA A UN D SD

Appendix C

Adaptation of High School-Science Teaching Efficacy Belief Instrument-Biology

Adaptation of High School-Science Teaching Efficacy Belief Instrument-Biology	
Original STEBI-chem	**Adapted HS-STEBI-bio**
1.When a student does better in the chemistry section of science it is often because the teacher exerted a little extra effort	1. When a student does better than usual in biology, it is often because the teacher exerted a little extra effort.
2.I am continually finding better ways to teach chemistry.	2. I continuously find better ways to teach biology.
3.Even when I try very hard, I do not teach chemistry as well as I do most areas of science.	3. Even if I try very hard, I do not teach biology as well as I teach other sciences.
4.When students grades in the chemistry section of science improve it is often due to their teacher having found a more effective teaching approach.	4. When the biology grades of students improve, it is often due to their teacher having found a more effective teaching approach.
5.I know the steps necessary to teach chemistry concepts effectively.	5. I am able to teach biology concepts effectively.
6.I am not very effective in monitoring chemistry experiments.	6. I am effective in monitoring hands-on biology activities.
7.If students are underachieving in the chemistry section of science it is most likely due to ineffective chemistry teaching.	7. If students are underachieving in biology, it is most likely due to ineffective teaching.
8	Omitted
9.The inadequacy of a student’s background in chemistry can be overcome by good teaching.	9. The inadequacy of a student's background in the science of biology can be overcome by good teaching.
10.The low science achievement of some students in the chemistry section of science cannot be blamed on their teachers.	10. The low science achievement of some students in biology cannot be blamed on their teachers.
11.When a low-achieving child progresses in the chemistry section of science it is usually due to extra attention given by the teacher.	11. When a low-achieving student progresses in biology, it is usually due to extra attention given by the teacher.
12.I understand chemistry concepts well enough to be effective in teaching middle school chemistry	12. I understand biology concepts well enough to be an effective high school biology teacher.
13.Increased effort in chemistry teaching produces little change in some students chemistry achievement.	13. Increased effort in teaching biology produces little change in students' biology achievement.
14.The teacher is generally responsible for the achievement of students in the chemistry section of science.	14. The teacher is generally responsible for the achievement of students in biology.
15.Students achievement in the chemistry section of science is directly related to their teachers effectiveness in teaching.	15. Students' achievement in biology is directly related to their teachers' effectiveness.
16.If parents comment that their child is showing more interest in the chemistry section of science at school, it is probably due to performance of the child’s teacher.	16. If parents comment that their child is showing more interest in biology at school, it is probably due to performance of the child's teacher.
17.I find it difficult to explain to students why chemistry experiments work.	17. I find it easy to use hands-on activities such as experiments and demonstrations to explain biology concepts to students.
18.I am typically able to answer students’ chemistry questions	18. 1 am able to answer students' biology questions
19.I wonder if I have the necessary skills to teach the chemistry section of science.	19. I wonder if I have the necessary skills to teach biology.

20.Effectiveness in chemistry teaching has little influence on the achievement of students with low motivation.	20. Effective biology teachers influence low-motivated students' achievement.
21.Given the choice I would not invite the principal to evaluate my science teaching in chemistry.	21. Given a choice, I would not invite my principal to evaluate my biology teaching .
22.When a student has difficulty understanding a chemistry concept I am usually at a loss as to how to help the student understand it better.	22. When a student has difficulty understanding a biology concept, I am usually at a loss as to how to help the student understand it better.
23.When teaching chemistry, I usually welcome students’ questions.	23. When teaching biology, I usually welcome students’ questions.
24.I do not know what to do to turn students on to chemistry.	24. I do not know what to do to turn students on to biology.
25.Even teachers with good teaching abilities cannot help some kids to learn chemistry.	25. Even teachers with good teaching abilities cannot help some students to learn biology.

Appendix D

High School - Science Teaching Efficacy Belief Instrument-Bio

High School - Science Teaching Efficacy Belief Instrument-Bio
Please indicate the degree to which you agree or disagree with each statement below by checking appropriate box to the right of each statement. SA = STRONGLY AGREE A = AGREE UN = UNCERTAIN D = DISAGREE SD = STRONGLY DISAGREE Note: Item 10 and item 13 were deleted

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

2. I continuously find better ways to teach biology. SA A N D SD

3. Even if I try very hard, I do not teach biology as well as I teach other science subjects. SA A N D SD

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

5. I am able to teach biology concepts effectively. SA A N D SD

6. I am effective in monitoring hands-on biology activities. SA A N D SD

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

8. I generally teach biology concepts ineffectively. SA A N D SD

9. The inadequacy of a student's background in the science of biology can be overcome by good teaching. SA A N D SD

~~*10. The low science achievement of some students in biology cannot be blamed on their teachers.~~

11. When a low-achieving student progresses in biology, it is usually due to extra attention given by the teacher. SA A N D SD

12. I understand biology concepts well enough to be an effective high school biology teacher. SA A N D SD

~~*13. Increased effort in teaching biology produces little change in students' biology achievement.~~

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

15. Students' achievement in biology is directly related to their teachers' effectiveness. SA A N D SD

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

17. I find it easy to use hands-on activities such as experiments and demonstrations to explain biology concepts to students. SA A N D SD

18. I am able to answer students' biology questions. SA A N D SD
19. I wonder if I have the necessary skills to teach biology. SA A N D SD
20. Effective biology teachers influence low-motivated students' achievement. SA A N D SD
21. Given a choice, I would not invite my principal to evaluate my biology teaching. SA A N D SD
22. When a student has difficulty understanding a biology concept, I am usually at a loss as to how to help the student understand it better. SA A N D SD
23. When teaching biology, I usually welcome students' questions. SA A N D SD
24. I do not know what to do to turn students on to biology. SA A N D SD
25. Even teachers with good teaching abilities cannot help some students to learn biology. SA A N D SD

Note: *Item deleted

Demographic Information

Are you certified by the state of Texas to teach science in high school?
Do you teach in a public high school in Texas?
Do you teach any section biology this school year (2017-2018)?
How many years have you taught biology in high school?
What is your gender?

- Male
- Female

What was your undergraduate major?
What was your undergraduate minor?

- What high school science certification(s) do you possess? Please check all that apply? - Composite science (science 7-12 or science 8-12)
- Life science
- Physical science
- Biology
- Chemistry
- Physics
- Other (please specify)

How did you obtain your certification(s)?

- Alternative route
- Traditional route
- Other (please explain)

Did you take a science certification exam?

- Yes
- No

If yes, how long ago did you take the science certification exam?

- Less than 5 years
- Less than 10 years
- Less than 15 years
- Less than 20 years
- 20 + years

What is your race/ethnicity?
Caucasian/White, non-Hispanic
African American/Black, non-Hispanic
Hispanic
Other(please specify)
Have you taught other science courses in high school?

- Yes
- No

What other science courses have you taught in the past?
How many years have you taught science (any course) in high school?
What is your school location?

Appendix E

High School - Science Teaching Efficacy Belief Instrument-phys

High School - Science Teaching Efficacy Belief Instrument-phys
Please indicate the degree to which you agree or disagree with each statement below by checking appropriate box 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 physics, it is often it is often because the teacher exerted a little extra effort. SA A N D SD

2. I continuously find better ways to teach physics SA A N D SD

3. Even if I try very hard, I do not teach physics as well as I teach other science subjects. SA A N D SD

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

5. I am able to teach physics concepts effectively. SA A N D SD

6. I am effective in monitoring hands-on physics activities. SA A N D SD

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

8. I generally teach physics concepts ineffectively. SA A N D SD

9. The inadequacy of a student's background in the science of physics can be overcome by good teaching. SA A N D SD

10. The low science achievement of some students in physics cannot be blamed on their teachers. SA A N D SD

11. When a low-achieving student progresses in physics, it is usually due to extra attention given by the teacher. SA A N D SD

12. I understand physics concepts well enough to be an effective high school physics teacher. SA A N D SD

13. Increased effort in teaching physics produces little change in students' physics achievement. SA A N D SD

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

15. Students' achievement in physics y is directly related to their teachers' effectiveness. SA A N D SD

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

17. I find it easy to use hands-on activities such as experiments and demonstrations to explain physics concepts to students. SA A N D SD

18. I am able to answer students' physics questions.	SA A N D SD
19. I wonder if I have the necessary skills to teach physics.	SA A N D SD
20. Effective physics teachers influence low-motivated students' achievement.	SA A N D SD
21. Given a choice, I would not invite my principal to evaluate my physics teaching.	SA A N D SD
22. When a student has difficulty understanding a physics concept, I am usually at a loss as to how to help the student understand it better.	SA A N D SD
23. When teaching physics, I usually welcome students' questions.	SA A N D SD
24. I do not know what to do to turn students on to physics.	SA A N D SD
25. Even teachers with good teaching abilities cannot help some students to learn physics.	SA A N D SD

Demographic Information

Are you certified by the state of Texas to teach science in high school?

- Yes
- No

Do you teach in a public high school in Texas?

- Yes
- No

Do you teach any section physics this school year (2017-2018)?

- Yes
- No

How many years have you taught biology in high school?

What is your gender?

- Male
- Female

What was your undergraduate major?

What was your undergraduate minor?

What high school science certification(s) do you possess? Please check all that apply? –

- Composite science (science 7-12 or science 8-12)
- Life science
- Physical science
- Biology
- Chemistry
- Physics
- Other (please specify)

How did you obtain your certification(s)?

- Alternative route
- Traditional route
- Other (please explain)

Did you take a science certification exam?

- Yes
- No

If yes, how long ago did you take the science certification exam?

- Less than 5 years
- Less than 10 years
- Less than 15 years
- Less than 20 years
- 20 + years

What is your race/ethnicity?

Caucasian/White, non-Hispanic

African American/Black, non-Hispanic

Hispanic

Other(please specify)

Have you taught other science courses in high school?

- Yes
- No

What other science courses have you taught in the past?

How many years have you taught science (any course) in high school?

What is your school location?

Appendix F

High School - Science Teaching Efficacy Belief Instrument-chem

High School - Science Teaching Efficacy Belief Instrument-chem
Please indicate the degree to which you agree or disagree with each statement below by checking appropriate box 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 chemistry, it is often it is often because the teacher exerted a little extra effort. SA A N D SD

2. I continuously find better ways to teach chemistry SA A N D SD

3. Even if I try very hard, I do not teach chemistry as well as I teach other science subjects. SA A N D SD

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

5. I am able to teach chemistry concepts effectively. SA A N D SD

6. I am effective in monitoring hands-on chemistry activities. SA A N D SD

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

8. I generally teach chemistry concepts ineffectively. SA A N D SD

9. The inadequacy of a student's background in the science of chemistry can be overcome by good teaching. SA A N D SD

10. The low science achievement of some students in chemistry cannot be blamed on their teachers. SA A N D SD

11. When a low-achieving student progresses in chemistry, it is usually due to extra attention given by the teacher. SA A N D SD

12. I understand chemistry concepts well enough to be an effective high school chemistry teacher. SA A N D SD

13. Increased effort in teaching chemistry produces little change in students' chemistry achievement. SA A N D SD

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

15. Students' achievement in chemistry is directly related to their teachers' effectiveness. SA A N D SD

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

17. I find it easy to use hands-on activities such as experiments and demonstrations to explain chemistry concepts to students. SA A N D SD

18. I am able to answer students' chemistry questions. SA A N D SD

19. I wonder if I have the necessary skills to teach chemistry. SA A N D SD
20. Effective chemistry teachers influence low-motivated students' achievement. SA A N D SD
21. Given a choice, I would not invite my principal to evaluate my chemistry teaching. SA A N D SD
22. When a student has difficulty understanding a chemistry concept, I am usually at a loss as to how to help the student understand it better. SA A N D SD
23. When teaching chemistry, I usually welcome students' questions. SA A N D SD
24. I do not know what to do to turn students on to chemistry. SA A N D SD
25. Even teachers with good teaching abilities cannot help some students to learn chemistry. SA A N D SD

Demographic Information

Are you certified by the state of Texas to teach science in high school?

- Yes
- No

Do you teach in a public high school in Texas?

- Yes
- No

Do you teach any section chemistry this school year (2017-2018)?

- Yes
- No

How many years have you taught biology in high school?

What is your gender?

- Male
- Female

What was your undergraduate major?

What was your undergraduate minor?

What high school science certification(s) do you possess? Please check all that apply? –

- Composite science (science 7-12 or science 8-12)
- Life science
- Physical science
- Biology
- Chemistry
- Physics
- Other (please specify)

How did you obtain your certification(s)?

- Alternative route
- Traditional route
- Other (please explain)

Did you take a science certification exam?

- Yes
- No

If yes, how long ago did you take the science certification exam?

- Less than 5 years
- Less than 10 years
- Less than 15 years
- Less than 20 years
- 20 + years

What is your race/ethnicity?

Caucasian/White, non-Hispanic

African American/Black, non-Hispanic

Hispanic

Other(please specify)

Have you taught other science courses in high school?

- Yes
- No

What other science courses have you taught in the past?

How many years have you taught science (any course) in high school?

What is your school location?

Appendix G

Pilot Study

Pilot Study

The aim of the pilot study was mainly instrumentation. The purpose and process of modifying the existing Science Teaching Efficacy Belief Instrument (STEBI) was discussed. Additionally, validity, reliability tests, and results of the modified instrument were included in the study.

Purpose

The STEBI (Appendix A), a 25-item Likert scale, developed by Riggs and Enochs (1990), was intended for studies involving beliefs of elementary teachers in teaching and learning science. The data for developing the instrument were collected from in-service elementary teachers. Through factor analysis, Riggs and Enochs (1990) obtained two subscales (factors), Personal Science Teaching Efficacy Beliefs and Science Teaching Outcome Expectancy. The first factor was defined by 13 items and the second with 12 variables. Riggs and Enochs (1990) recommended that the Science Teaching Efficacy Belief Instrument be used as a tool for studies involving elementary teachers' efficacy beliefs. Consequently, scholars adapted the instrument in various studies involving elementary teachers. For example, Wenner (2001) altered the wording of STEBI to obtain mathematics information and used the modified scale to compare efficacy beliefs of in-service and pre-service elementary school teachers in math and science. In addition, Enochs, Smith, and Huinker (2000) adapted STEBI to study mathematics teaching efficacy beliefs of elementary school teachers.

For middle grade use, Rubeck (1990) modified STEBI by replacing the word 'science' with 'chemistry' and measured efficacy beliefs of middle school chemistry teachers. Rubeck (1990) named the instrument STEBI-chem (Appendix B). Through factor analysis, Rubeck (1990) obtained two factors consistent with STEBI (Riggs & Enochs).

Rubeck named the first factor “subscale self-efficacy in chemistry teaching” and the second factor, “outcome expectancy in chemistry teaching.”

The efficacy construct is both content and context specific (Bandura, 1977). The situational differences of the original STEBI and STEBI-chem differ from the current study. The original STEBI was validated with in-service elementary teachers and the STEBI-chem with middle school teachers. The elementary school science is usually taught as general science, unlike high school science, which is often taught as separate subjects. Although the STEBI-chem was subject-specific similar to core high school subjects in this study, the context is different. Hence, there is a need and opportunity to adapt STEBI for the current study and examine the psychometric properties.

The STEBI-chem was chosen for this study because original STEBI is more for measures involving efficacy beliefs in teaching general science while STEBI-chem is specific to a particular science subject matter. The modified STEBI-chem is named “High School-Science Teaching Efficacy Belief Instrument (HS-STEBI) to differentiate it from STEBI and STEBI-chem. Each science subject matter is added with a hyphen at the end of HS-STEBI (i.e., -phys, -bio, or -chem) to identify the physics scale, biology scale or chemistry scale. The biology scale was named HS-STEBI-bio (Appendix D), and the physics scale HS-STEBI-phys (Appendix E). The chemistry instrument was introduced in the primary study and was named HS-STEBI-chem (Appendix F).

The HS-STEBI-bio (High School-Science Teaching Efficacy Belief Instrument-biology) was the first to be developed. Alterations were made on STEBI-chem by replacing the word chemistry with biology and by changing or deleting some phrases to suit the study. For example, “Even when I try very hard, I do not teach chemistry as well as I do most areas of science,” is a variable in STEBI- chem. To obtain information for HS-STEBI-bio, the term ‘chemistry’ was replaced with ‘biology,' and the phrase, ‘most areas of science’ was changed to ‘other science subjects.' Also, “When student’s grades in the chemistry section of science improve it is often due to their teacher having found a more effective teaching approach” is a STEBI-chem item. To obtain a HS-STEBI-phys variable, the word ‘chemistry’ was changed to ‘biology’ and the phrase ‘section of science’ was completely deleted (see Appendix C for all alterations). Table G1 shows a sample of STEBI-chem and corresponding HS-STEBI-bio.

Once the HS-STEBI-bio information was obtained, HS-STEBI-phys (Appendix E) was created by removing the word biology and replacing it with physics. The HS-STEBI-chem was obtained similarly. Thus, HS-STEBI-bio, HS-STEBI-phys, and HS-STEBI-chem are three similar, but parallel instruments. The only alteration made between the three instruments was substituting the word “physics” for “biology”, or “chemistry.” Table G2 shows modification of HS-STEBI-bio to HS-STEBI-phys.

Table G1

STEBI-chem and Corresponding HS-STEBI-bio

STEBI-chem	HS-STEBI-bio
3. Even when I try very hard, I do not teach ‘chemistry’ as well as I ‘do most areas of science.’	3. Even if I try very hard, I do not teach ‘biology’ as well as I teach ‘other science subjects.’
4. When students’ grades in the ‘chemistry section of science’ improve, it is often due to their teacher having found a more effective teaching approach.	4. When the ‘biology’ grades of students improve, it is often due to their teacher having found a more effective teaching approach.

Table G2

Adapting HS-STEBI-bio to HS-STEBI-phys

HS-STEBI-bio	STEBI-phys

3. Even if I try very hard, I do not teach 'biology' as well as I teach other sciences.	3. Even if I try very hard, I do not teach 'physics' as well as I teach other sciences.
4. When the 'biology' grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4. When the 'physics' grades of students improve, it is often due to their teacher having found a more effective teaching approach.

Dr. Catherine Horn, a survey research methodologist from whose class the studies began, assisted with the alteration of words in STEBI-chem to obtain biology and physics information and with grammar and punctuation before the instrument was administered to the respondents. In both STEBI-bio and STEBI-phys, each question was a statement followed by a five-point Likert Scale: 'strongly disagree,' 'disagree,' 'neither agree nor disagree,' 'agree,' and 'strongly agree.' In the five-point Likert scale, teachers with high teaching efficacy are expected to score 5 on items that indicate strong agreement and 1 on items that indicate strong disagreement.

Participants and Data Collection

Data were collected from in-service science teachers in public high schools in Texas. The teachers earned a standard certification in either science composite, life science, chemistry, biology, physics, or physical science. The participants taught biology or physics in the 2013-2014 academic year. The subjects were selected from 120 schools in 24 different independent school districts in Texas. The districts were located in rural, urban, or suburban areas. The sampling technique was through convenience sampling. The investigator visited school websites and obtained email addresses of the teachers in the sample. A survey was distributed online by Qualtrics, an online platform, to a total of 822-panel members; however, only 59 teachers completed the physics scale, and 46 teachers responded to the biology instrument.

The survey was intended to be administered to high school biology and physics teachers in the state of Texas. However, science teachers most often teach multiple science courses, hence the teachers were sampled without paying attention to the type of science courses taught. A “skip logic” feature on Qualtrics was used to exclude, include, and directly sample participants as follows: The second question on the survey read: “Do you teach any section of high school physics this year (2013-2014)?” Science teachers who answered ‘no’ to physics question above ‘skip’ to biology. A similar question was asked in the biology section: “Do you teach any section of high school biology this year (2013-2014)?” Those who answered ‘no’ to the biology question “skipped” to the end of the survey and exited. Hence, the ‘skip logic’ allowed only biology and physics teachers to complete the survey and excluded other science teachers. The teacher participants were also asked to specify their science certification field. Data were imported into the SPSS data file for analysis. The pilot study contained 45 items that included adapted STEBI variables and 20 additional variables. However, only 24 STEBI items were analyzed and item 8 on the STEBI was inadvertently omitted.

Psychometric

There are four main reasons why it was deemed necessary to first validate the reliability and validity of HS-STEBI-phys and HS-STEBI-bio in a pilot study. First, existing teacher efficacy belief instruments often have problems with validity and reliability (Tschannen-Moran Hoy, 2001). Secondly, teacher efficacy beliefs are both context and subject-matter specific and as a result, “a teacher may feel very competent in one area of study or when working with one kind of student and feel less able in other subjects or with different students” (Tschannen-Moran & Hoy, 2001, p. 790). The STEBI-chem was used with middle school chemistry teachers. Additionally, Riggs and Enochs (1990) created STEBI specifically for elementary grade science teachers. The word “science” is broad. In high school, science splits into different disciplines such as biology, physics, and chemistry, and the sciences are taught as a separate subject in most cases. The psychometric properties of a general science instrument such as STEBI may be different or similar to features of STEBI adapted for a particular science subject. Moreover, data for validating STEBI were collected from elementary teachers (Riggs & Enochs,1990).

Teachers within this group frequently teach general science to younger students and often do not hold an undergraduate degree in a specific science subject, when compared to high school academic science teachers. The current study involved high school teachers who often teach older students, adolescent boys and girls. Therefore, the context under which STEBI was validated was different. The purpose was also different since general science is somewhat different from a specific science subject.

Therefore, it is important to determine psychometric properties of modified STEBI before applying it to the current study. In addition, studies are yet to resolve "the extent to which teacher efficacy is unique to given contexts and to what extent efficacy beliefs are transferable across contexts" (Tschannen-Moran & Hoy, 2001, p. 784), hence reiterating the importance of evaluating validity and reliability of teacher efficacy belief scale whenever context changes. Though Enochs, Huinker, and Smith (2000) mentioned that some researchers who used several of adaptations of STEBI relied on already established validity, many other researchers studied the psychometric properties of adapted STEBI (Rubeck, 1990; Enochs, Smith & Huinker, 2000; Wenner, 2001). The pilot study examined the validity and reliability of the adapted STEBI.

Data Analysis

Exploratory Factor Analysis of HS-STEBI-bio

An exploratory factor analysis by Principal Component Analysis was conducted on the 24-item HS-STEBI-bio using IBM SPSS statistics. The number of principal components to extract was fixed to two, because of the prior theory that STEBI has two subscales (Riggs & Enochs, 1990; Rubeck, 1990). Also, Bandura (1977, 1997) theorized two-path efficacy beliefs, personal efficacy and outcome expectancy. The components were rotated using varimax orthogonal rotation. The scree plot test showed inflexion that justified retention of two principal components (Figure G1) and hence verified that STEBI-bio has two factors. However, there were seven principal components with eigenvalues > 1 thereby suggesting more important components could be retained (Keiser, 1960 in Field, 2013). A decision that two factors could be a solution was based on the scree plot results (Figure G1). The first principal component had an eigenvalue of 5.68 and explained 23.66 percent of the total variance. The second component recorded an eigenvalue of 3.79 and accounted for 15.79 percent of the total variance. These results were comparable to that obtained by Riggs and Enochs (1990).

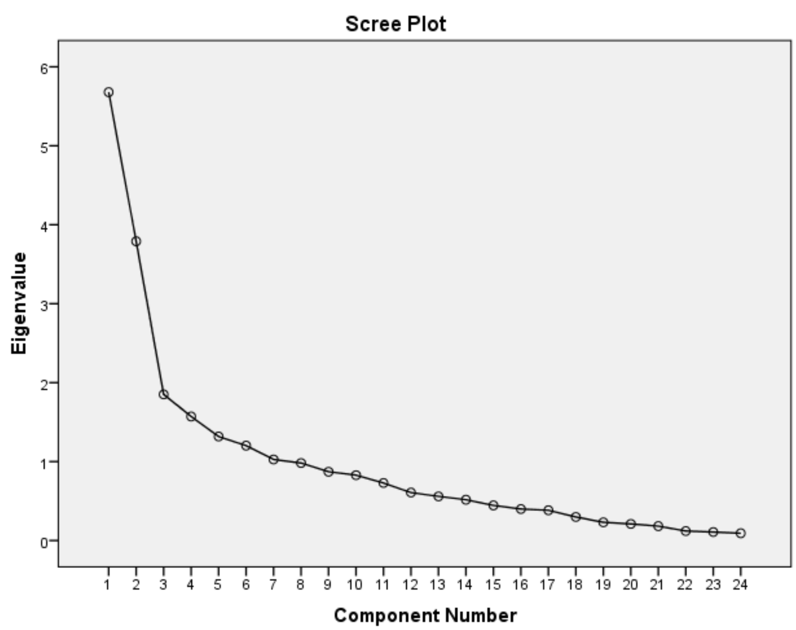

Figure G1 Scree plot of 24-item STEBI-bio.

The results in Table G3 show loadings on each principal component. A total of 12 items loaded into component one. The items were consistent with variables which constituted factor one in Rubeck's (1990) STEBI-chem and the first factor in the original STEBI by Riggs and Enochs (1990). The same loading consistency was observed for the second component. All variables with high loadings in the first component strongly correlated with component one more than the second principal component. Similar loading consistency was observed to be true in the second component. For example, items (2, 3, 5, 6, 12, 17, 18, 19, 21, 22, 23, and 24) are associated with component one, because the variables have higher loadings in principal component one more than component two. Item 17 seemed to cross-load on both components, but with a slightly higher loading with component 1. The variable 25 showed a loading less than .3, the lowest criterion for determining an important item for a factor (Field, 2013), however, both items 17 and 25 were not discarded due to the prior theory on the positions of the items on the existing instrument. The first principal component was named "Personal Efficacy in Teaching Biology Teaching" The second principal component was labeled "Outcome Expectancy in Teaching Biology Teaching" (OEBT).

Table G3

Rotated Component Metrix Loadings on STEBI-bio

	Component	
	1	2
22. When a student has difficulty understanding a biology concept, I am usually at a loss as to how to help the student understand it better.	-.761	
18. I am able to answer students' biology questions.	.758	
5. I am able to teach biology concepts effectively.	.735	
19. I wonder if I have the necessary skills to teach biology.	-.696	
24. I do not know what to do to turn students on to biology.	-.696	
6. I am effective in monitoring hands-on biology activities.	.675	
23. When teaching biology, I usually welcome students' questions.	.649	
12. I understand biology concepts well enough to be an effective high school biology teacher.	.590	
3. Even if I try very hard, I do not teach biology as well as I teach other sciences.	-.564	
2. I continuously find better ways to teach biology.	.555	
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain biology concepts to students.	.486	
21. Given a choice, I would not invite my principal to evaluate my biology teaching.	-.419	
14. The teacher is generally responsible for the achievement of students in biology.		.706
7. If students are underachieving in biology, it is most likely due to ineffective teaching.		.692
4. When the biology grades of students improve, it is often due to their teacher having found a more effective teaching approach.		.680
15. Students' achievement in biology is directly related to their teachers' effectiveness.		.674
1. When a student does better than usual in biology, it is often because the teacher exerted a little extra effort.		.617
13. Increased effort in teaching biology produces little change in some students' biology achievement.		-.567
11. When a low-achieving student progress in biology, it is usually due to extra attention given by the teacher.		.563
20. Effective biology teachers influence low-motivated students' achievement.		.533
10. The low science achievement of some students in biology cannot be blamed on their teachers.		-.525
9. The inadequacy of a student's background in the science of biology can be overcome by good teaching.		.480
16. If parents comment that their child is showing more interest in biology at school, it is probably due to performance of the child's teacher.		.399
25. Even teachers with good teaching abilities cannot help some students to learn biology.		-.296

Reliability Test

Before performing the reliability test, all items with negative loadings were reverse-scored. For example, item 24 “I do not know what to do to turn students on to biology.” was negatively worded and scored as, 1 = strongly disagree, 2 = disagree, 3 = neither, 4 = agree, and 5 = strongly agree, in the survey. However, a strong disagreement for items such as 24 indicated efficaciousness. Hence, items (3, 10, 13, 19, 21, 22, 24, and 25) were negative items and hence were reverse-scored as 1 = strongly agree, 2 = agree, 3 = neither, 4 = disagree, and 5 = strongly disagree, before reliability testing was performed.

An internal consistency reliability of both Personal Efficacy in Teaching Biology (PETB) and Outcome Expectancy in Teaching Biology (OETB) subscales was conducted using Cronbach’s alpha. The PETB subscale produced overall alpha of .84, shown in Table G4. All items in PEBT have Corrected Item-Total Correlation above .3. The OETB subscales registered overall Cronbach’s alpha of .79, and each variable has Corrected Item-Total Correlation of .3 except items 15 and 25 as shown in Table G5. The items were not deleted due to the overall reliability of the good subscale. The overall reliability of both PETB and OETB scales were comparable to that obtained by Riggs and Enochs (1990) and Rubeck (1990).

The results obtained from Principal Component Analysis and reliability tests seemed to indicate that HS-STEBI-bio is a valid and reliable instrument to measure teacher efficacy beliefs about biology teaching. It appears to mean that alteration of the instrument and administration to high school biology teachers, a population different from elementary teachers for which the first STEBI was developed for, did not alter the consistency of the instrument.

Table G4

Reliability Statistics of Personal Efficacy in Teaching Biology

Overall α = .84

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
2. I continuously find better ways to teach biology.	.439	.836
5. I am able to teach biology concepts effectively.	.627	.827
6. I am effective in monitoring hands-on biology activities.	.601	.825
12. I understand biology concepts well enough to be an effective high school biology teacher.	.485	.832
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain biology concepts to students.	.419	.842
18. I am able to answer students' biology questions.	.647	.824
23. When teaching biology, I usually welcome students' questions.	.530	.833
Item 3. Even if I try very hard, I do not teach biology as well as I teach other sciences.	.436	.836
Item 19. I wonder if I have the necessary skills to teach biology.	.593	.824
Item 21 Given a choice, I would not invite my principal to evaluate my biology teaching.	.360	.849
Item 22 When a student has difficulty understanding a biology concept, I am usually at a loss as to how to help the student understand it better.	.676	.818
Item 24. I do not know what to do to turn students on to biology.	.630	.821

Table G5

Reliability Statistics for Outcome Expectancy in Teaching Biology

Overall α =.79

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1. When a student does better than usual in biology, it is often because the teacher exerted a little extra effort.	.431	.775
4. When the biology grades of students improve, it is often due to their teacher having found a more effective teaching approach.	.521	.766
7. If students are underachieving in biology, it is most likely due to ineffective teaching.	.630	.753
9. The inadequacy of a student's background in the science of biology can be overcome by good teaching.	.397	.778
11. When a low-achieving student progress in biology, it is usually due to extra attention given by the teacher.	.525	.767
14. The teacher is generally responsible for the achievement of students in biology.	.541	.763
*15. Students' achievement in biology is directly related to their teachers' knowledge of biology content.	.283	.790
16. If parents comment that their child is showing more interest in biology at school, it is probably due to performance of the child's teacher.	.342	.783
20. Effective biology teachers influence low-motivated students' achievement.	.454	.775
Item 10. The low science achievement of some students in biology cannot be blamed on their teachers.	.406	.777
Item 13. Increased effort in teaching biology produces little change in some students' biology achievement.	.486	.769
*Item 25 Even teachers with good teaching abilities cannot help some students to learn biology	.252	.793

Ideally, a Confirmatory Factor Analysis (CFA) will usually be performed to support the validity of HS-STEBI-bio as an instrument with valid two components. Hence, a CFA test was performed to support the validity of HS-STEBI-bio. Figure G2 shows the path diagram and pattern coefficient of the STEBI-bio model. The "goodness of fit" of the model was determined with three indexes, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Comparative Fit Index (NFI). The Goodness of Fit (GF1) index could not be estimated due to missing data as the analysis was performed without "modification indices" and with "estimate means and intercepts." The results showed that RMSEA = .05, CFI = .75, and NFI = .45. The NCI and CFI were less than .95. The "NFI and CFI should achieve a value of .95 for the model to be deemed a good fit" (Meyers, Gamst & Guarino, 2006, p. 873). Therefore, the HS-STEBI-bio model is not a good fit for the data. The goodness of fit test seems to have failed due to the small sample size used in this pilot study. Sample size influences results of confirmatory factor analysis; 200 to 400 sample sizes is adequate for models with more than ten indicators (Meyers et al., 2006). The latent variable has more than ten indicators. Only 46 participants took part in the survey. The CFA will be repeated in the current study with a larger sample size.

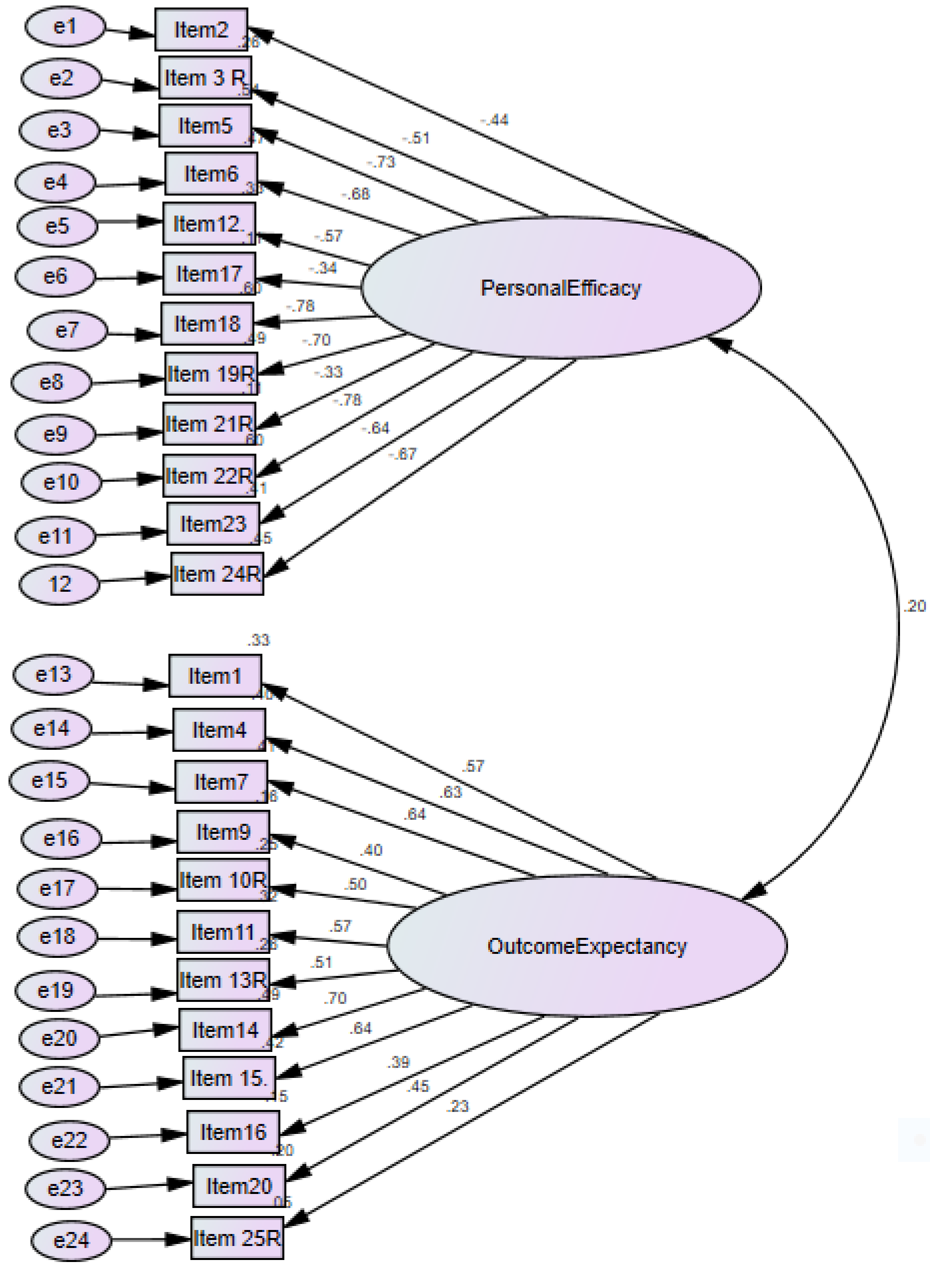

Figure G2. Path diagram of the HS-STEBI-bio model.

Exploratory Factor Analysis of HS-STEBI-phys

The variables which constituted HS-STEBI-phys were analyzed in a manner similar to those of STEBI-bio. Principal Component Analysis (PCA) with varimax orthogonal rotation was used to extract two fixed factors from the 24 items using IBM SPSS statistics. The two extracted components have eigenvalues over Kaiser's criterion of 1. The scree plot suggested that two components are retainable as the components are distinctly located to the left of point of inflexion as shown in Figure G3.

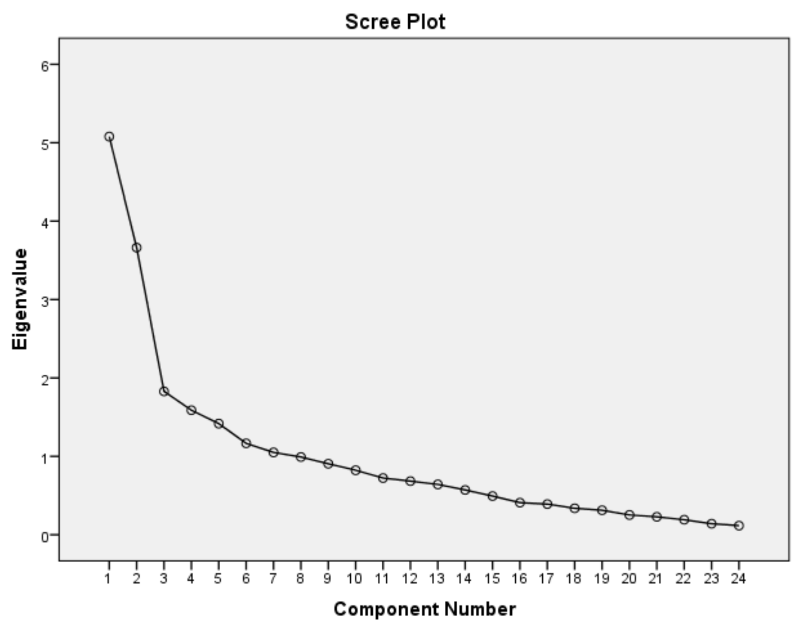

Figure G3. Scree plot of HS-STEBI-phys.

The loadings for items on both principal components are presented in Table G6. A total of 14 variables correlated with the first principal component and ten items loaded into the second component. The PCA results from the 24 items in STEBI-phys seem to show a small deviation from STEBI-chem in Rubeck (1990) and STEBI (Riggs & Enochs (1990). Though analysis yielded a two-dimensional component as observed by Riggs and Enochs (1900) and Rubeck (1990), the positions of the components were reversed. The first component is outcome-expectancy and not personal efficacy. Also, item 5 ("I am able to teach physics concepts effectively.”), and item 22 (“When a student has difficulty understanding a physics concept, I am usually at a loss as to how to help the student understand it better.”) which are personal efficacy variables, seem to cross load into both subscales. But the items leaned toward greater correlation with the outcome-expectancy subscale.

When item 5 was removed from the PCA, item 22 continued to load as an outcome-expectancy variable. Also, when item 5 was put back and item 22 removed, item 5 still loaded as an outcome expectancy variable. The two items were then removed from further analysis, and PCA was run again. The results are presented in Table G7.

Table G6

Rotated Component Matrix showing Loadings of Principal Components in HS-STEBI-phys

	Component	
	1	2
20. Effective physics teachers influence low-motivated students' achievement.	.701	
11. When a low-achieving student progresses in physics, it is usually due to extra attention given by the teacher.	.688	
15. Students’ achievement in physics is directly related to their teachers' effectiveness.	.687	
14. The teacher is generally responsible for the achievement of students in physics.	.663	
4. When the physics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	.657	
7. If students are underachieving in physics, it is most likely due to ineffective teaching.	.618	
9. The inadequacy of a student's background in the science of physics can be overcome by good teaching.	.486	
25. Even teachers with good teaching abilities cannot help some students to learn physics.	-.478	.
10. The low science achievement of some students in physics cannot be blamed on their teachers.	-.456	
16. If parents comment that their child is showing more interest in physics at school, it is probably due to the performance of the child's teacher.	.436	
13. Increased effort in teaching physics produces little change in students' physics achievement.	-.412	
5*. I am able to teach physics concepts effectively.	-.396	
22*. When a student has difficulty understanding a physics concept, I am usually at a loss as to how to help the student understand it better.	-.360	
1. When a student does better than usual in physics, it is often because the teacher exerted a little extra effort.	-.248	
12. I understand physics concepts well enough to be an effective high school physics teacher.		.834
19. I wonder if I have the necessary skills to teach physics.		-.767
23. When teaching physics, I usually welcome students’ questions.		.707
18. I am able to answer students' physics questions.		.668
3. Even if I try very hard, I do not teach physics as well as I teach other sciences.		-.666
24. I do not know what to do to turn students on to physics.		-.573
6. I am effective in monitoring hands-on physics activities		.564
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain physics concepts to students.		.456
2. I continuously find better ways to teach physics.		.422
21. Given a choice, I would not invite my principal to evaluate my physics teaching.		-.302

Table G7

Rotated Component Matrix showing Loadings of HS-STEBI-phys; Items 5 and 22 Removed

	Component 1	Component 2
15. Students' achievement in physics is directly related to their teachers' effectiveness.	.695	
20. Effective physics teachers influence low-motivated students' achievement.	.692	
4. When the physics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	.683	
11. When a low-achieving student progresses in physics, it is usually due to extra attention given by the teacher.	.679	
14. The teacher is generally responsible for the achievement of students in physics.	.650	
7. If students are underachieving in physics, it is most likely due to ineffective teaching.	.604	
9. The inadequacy of a student's background in the science of physics can be overcome by good teaching.	.500	
25. Even teachers with good teaching abilities cannot help some students to learn physics.	-.486	
10. The low science achievement of some students in physics cannot be blamed on their teachers.	-.470	.
16. If parents comment that their child is showing more interest in physics at school, it is probably due to performance of the child's teacher.	.427	
13. Increased effort in teaching physics produces little change in students' physics achievement.	-.413	
1*. When a student does better than usual in physics, it is often because the teacher exerted a little extra effort.	-.273	
12. I understand physics concepts well enough to be an effective high school physics teacher.		.842
19. I wonder if I have the necessary skills to teach physics.		-.770
23. When teaching physics, I usually welcome students' questions.		.699
3. Even if I try very hard, I do not teach physics as well as I teach other sciences.		-.683
18. I am able to answer students' physics questions.		.657
24. I do not know what to do to turn students on to physics.		-.570
6. I am effective in monitoring hands-on physics activities.		.556
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain physics concepts to students.		.479
2. I continuously find better ways to teach physics.		.419
21. Given a choice, I would not invite my principal to evaluate my physics teaching.		-.319

Item 1 recorded weak loadings (-.27) and also had a negative correlation even though it is a positively worded variable. Item 1 was removed as a poor item, and a PCA was performed on the 21 remaining items. The results are presented in Table G8.

Table G8

Rotated Component Matrix Showing Loadings of HS-STEBI-phys;Items 5, 22 and 1 Removed

	Component	
	1	2
20. Effective physics teachers influence low-motivated students' achievement.	.695	
15. Students’ achievement in physics is directly related to their teachers' effectiveness.	.695	
11. When a low-achieving student progresses in physics, it is usually due to extra attention given by the teacher.	.677	
14. The teacher is generally responsible for the achievement of students in physics.	.664	
4. When the physics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	.663	
7. If students are underachieving in physics, it is most likely due to ineffective teaching.	.599	
25. Even teachers with good teaching abilities cannot help some students to learn physics.	-.504	
9. The inadequacy of a student's background in the science of physics can be overcome by good teaching.	.486	
10. The low science achievement of some students in physics cannot be blamed on their teachers.	-.477	
16. If parents comment that their child is showing more interest in physics at school, it is probably due to performance of the child's teacher.	.437	
13. Increased effort in teaching physics produces little change in students' physics achievement.	-.410	
12. I understand physics concepts well enough to be an effective high school physics teacher.		.843
19. I wonder if I have the necessary skills to teach physics.		-.767
23. When teaching physics, I usually welcome students’ questions.		.699
3. Even if I try very hard, I do not teach physics as well as I teach other sciences.		-.686
18. I am able to answer students' physics questions.		.654
24. I do not know what to do to turn students on to physics.		-.579
6. I am effective in monitoring hands-on physics activities.		.561
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain physics concepts to students.		.481
2. I continuously find better ways to teach physics.		.421
21. Given a choice, I would not invite my principal to evaluate my physics teaching.		-.312

The first component is defined with 11 variables and the second consisted of 10 items. A deviation from previously observed locations of the principal components could mean that physics teachers considered component one (outcome expectancy construct) more important than component two (personal efficacy). According to Field (2013), eigenvalues could be used to assess the importance of a factor because "eigenvalues associated with a variate indicate the substantive importance of that factor" (p. 877). Since component one has a higher eigenvalue (eigenvalue = 4.62) than component two (eigenvalue = 3.65), a reasonable explanation could be that physics teachers in the study seemed to consider their personal efficacy in teaching physics less important than outcome expectations.

The two-component variable accounted for 21.98 percent and 17.39 percent of the total variance, respectively. Normally, items are used to define a construct and because item loadings into each subconstruct are consistent with results obtained by Riggs and Enochs (1990) and Rubeck (1990), the first principal component in HS-STEBI-phys is named as factor two in STEBI-chem, Outcome Expectancy in Teaching Physics, and the second component is labeled as factor one in STEBI-chem, Personal Efficacy in Teaching Physics.

Reliability Testing of HS-STEBI-phys

The Cronbach's alpha was used to measure the internal reliability of Outcome Expectancy in Teaching Physics(OCTP) and Personal Efficacy in Physics Teaching (PETP) subscales and the components were measured separately without items 1, 5 and 22. Variables 25, 13, and 10 were reverse-coded before analysis. The reliability results are presented in Table G9. The overall α of OCTP subscale was .80. All the items have a Corrected Item-Total Correlation of .3 and above, except item 13. Ideally, items with less than a .3 Corrected Item-Total Correlation are from an instrument—because of the poor correlation with other variables and the tendency to lower the overall α of the scale.

However, item 13 was not deleted because the total reliability of the scale was good. Also, theory supports that item 13 is one of the variables that define outcome expectancy.

Additionally, the internal reliability coefficient of Personal efficacy in Teaching Physics was also determined using Cronbach's alpha. The results are presented in Table G10. The overall α for the PETP subscale was .77. All items have Corrected Item-Total Correlation of .3 and above except item 21, which has a very low value (.19) and influences overall reliability significantly. According to Field (2013), "If our questionnaire is reliable then we would not expect any one item to affect the overall reliability significantly, and no item should cause a substantial decrease in alpha" (Field, p. 711). Therefore, a decision was made to remove item 21 from the analysis. As a resi;t, the overall reliability improved to .81. Also, the Corrected Item-Total Correlation of the variables improved, as shown in Table G11.

The reliability coefficient of both subscales which form HS-STEBI-phys were good and comparable to results obtained by Riggs and Enochs (1990); and Rubeck (1990). The findings support that HS-STEBI-phys is a valid and reliable instrument to measure teacher efficacy beliefs of physics teachers in high schools. Thus, adapting the instrument and administrating it to high school physics teachers did not alter the internal consistency of the instrument.

Table G9

Reliability of Outcome Expectancy in Physics Teaching with Items 10 and 13

Overall α = .80

Variables	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
4. When the physics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	.583	.777
7. If students are underachieving in physics, it is most likely due to ineffective teaching.	.497	.784
9. The inadequacy of a student's background in the science of physics can be overcome by good teaching.	.403	.794
11. When a low-achieving student progresses in physics, it is usually due to extra attention given by the teacher.	.586	.775
14. The teacher is generally responsible for the achievement of students in physics.	.564	.777
15. Students' achievement in physics is directly related to their teachers' effectiveness.	.586	.775
16. If parents comment that their child is showing more interest in physics at school, it is probably due to performance of the child's teacher.	.325	.800
20. Effective physics teachers influence low-motivated students' achievement.	.573	.779
Item 10. The low science achievement of some students in physics cannot be blamed on their teachers.	.365	.799
Item 13. Increased effort in teaching physics produces little change in students' physics achievement.	.275	.809
25. Even teachers with good teaching abilities cannot help some students to learn physics.	.410	.795

Table G10

Reliability of Personal Efficacy in Physics Teaching with Item 21

Overall Reliability = .77

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
2. I continuously find better ways to teach physics.	.281	.768
6. I am effective in monitoring hands-on physics activities.	.475	.743
12. I understand physics concepts well enough to be an effective high school physics teacher.	.708	.721
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain physics concepts to students.	.437	.748
18. I am able to answer students' physics questions.	.394	.756
23. When teaching physics, I usually welcome students' questions.	.531	.748
3. Even if I try very hard, I do not teach physics as well as I teach other sciences.	.600	.723
19. I wonder if I have the necessary skills to teach physics.	.631	.719
Item 21. Given a choice, I would not invite my principal to evaluate my physics teaching.	.187	.807
24. I do not know what to do to turn students on to physics.	.472	.743

Table G11

Reliability of Personal Efficacy in Physics Teaching with Item 21 Removed

Overall alpha = .81

9 variables	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
2. I continuously find better ways to teach physics.	.311	.813
6. I am effective in monitoring hands-on physics activities.	.507	.787
12. I understand physics concepts well enough to be an effective high school physics teacher.	.742	.762
17. I find it easy to use hands-on activities such as experiments and demonstrations to explain physics concepts to students.	.401	.801
18. I am able to answer students' physics questions.	.436	.797
23. When teaching physics, I usually welcome students' questions.	.526	.792
3. Even if I try very hard, I do not teach physics as well as I teach other sciences.	.637	.768
19. I wonder if I have the necessary skills to teach physics.	.576	.777
Item 24. I do not know what to do to turn students on to physics.	.533	.785

Ideally, CFA is used to support the theory behind an existing instrument. Therefore, CFA was performed to test the model. The overall model was defective. The model indicators, NFI and CFI, did not reach critical values. NFI was .45 and CFI was .70. The RMSEA was .06. GFI was not estimated due to missing data. Removing items 2 and 21 did not significantly improve the model. The CFA will be reassessed in the current study with a larger sample size.

December 5, 2014

Philomena Agu
c/o Dr. John Ramsey
Curriculum and Instruction

Dear Philomena Agu,

Based upon your request for exempt status, an administrative review of your research proposal entitled "Biology and Physics Teacher Efficacy Beliefs: Instrument Validation by Two Science Teacher Groups" was conducted on October 31, 2014.

At that time, your request for exemption under **Category 4** was approved pending modification of your proposed procedures/documents.

The changes you have made adequately respond to the identified contingencies. As long as you continue using procedures described in this project, you do not have to reapply for review. * Any modification of this approved protocol will require review and further approval. Please contact me to ascertain the appropriate mechanism.

If you have any questions, please contact Nettie Martinez at 714-743-9211.

Sincerely yours,

Kirstin Rochford, MPH, CIP, CPIA
Director, Research Compliance

*Approvals for exempt protocols will be valid for 5 years beyond the approval date. Approval for this project will expire **December 4, 2019**. If the project is completed prior to this date, a final report should be filed to close the protocol. If the project will continue after this date, you will need to reapply for approval if you wish to avoid an interruption of your data collection.

Protocol Number: 15132-EX

316 E. Cullen Building Houston, TX 77204-2015 (713) 743-9204 Fax: (713) 743-9577

COMMITTEES FOR THE PROTECTION OF HUMAN SUBJECTS.

June 13, 2016

Philomena Agu
Curriculum and Instruction

Dear Philomena Agu,

Based upon your request for exempt status, an administrative review of your research proposal entitled "Exploratory and Confirmatory Construct Validation Studies of Adapted Science Teaching Efficacy Belief Instrument by Certified Biology and Physics Teachers" was conducted on May 6, 2016.

At that time, your request for exemption under **Category 2** was approved pending modification of your proposed procedures/documents.

The changes you have made adequately respond to the identified contingencies. As long as you continue using procedures described in this project, you do not have to reapply for review. * Any modification of this approved protocol will require review and further approval. Please contact me to ascertain the appropriate mechanism.

If you have any questions, please contact Alicia Vargas at (713) 743-9215.

Sincerely yours,

Kirstin Rochford, MPH, CIP, CPIA
Director, Research Compliance

*Approvals for exempt protocols will be valid for 5 years beyond the approval date. Approval for this project will expire **June 8, 2016**. If the project is completed prior to this date, a final report should be filed to close the protocol. If the project will continue after this date, you will need to reapply for approval if you wish to avoid an interruption of your data collection.

Protocol Number: 16419-EX

316 E. Cullen Building Houston, TX 77204-2015 (713) 743-9204 Fax: (713) 743-9577

COMMITTEES FOR THE PROTECTION OF HUMAN SUBJECTS.

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Institutional Review Boards

APPROVAL OF SUBMISSION

November 13, 2017

Philomena Agu

pagu@uh.edu

Dear Philomena Agu:

On November 7, 2017, the IRB reviewed the following submission:

Type of Review:	Modification/Update
Title of Study:	Exploratory and Confirmatory Construct Validation Studies of Adapted Science Teaching Efficacy Belief Instrument by Certified Biology and Physics Teachers
Investigator:	Philomena Agu
IRB ID:	MOD00000746
Funding/ Proposed Funding:	Name: Unfunded
Award ID:	None
Award Title:	
IND, IDE, or HDE:	None
Documents Reviewed:	• Email Script 10-05 updated.pdf, Category: Recruitment Materials; • MDR email contract, Category: Letters of Cooperation / Permission; • Protocol 11-05.pdf, Category: IRB Protocol; • Survey, Category: Study tools (ex: surveys, interview/focus group questions, data collection forms, etc.); • Consent 10-05.pdf, Category: Recruitment Materials;
Review Category:	Exempt
Committee Name:	Not Applicable
IRB Coordinator:	Sandra Arntz

The IRB approved the following revision on November 7, 2017; the approval end date for the research study remains June 8, 2021.

Summary of approved modification(s):

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1. The original protocol was made in RAMP. The current modifications require the use of the new HRP 503 template for ICON and not previously requested sections on RAMP was completed. Note that all modifications and form completion was added in red color.

2. Added chemistry teachers as participants and increased number of expected participants in each group to 1000,

3. Updated recruitment methods to reflect a purchase of email address from Market Data Retrieval Company (MDR), a division of Dun & Bradstreet, Inc. The MDR contract is attached contract.

4. Shortened title of the research project and added chemistry in the title,

5. Updated consent cover letter to HRP-502a and added the letter

6. Added survey link,

7. Added the entire survey to include chemistry, and

8. Added email script.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

Sincerely,

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Office of Research Policies, Compliance and Committees (ORPCC)
University of Houston, Division of Research
713 743 9204
cphs@central.uh.edu
http://www.uh.edu/research/compliance/irb-cphs/

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APPROVAL OF SUBMISSION

November 17, 2017

Philomena Agu

pagu@uh.edu

Dear Philomena Agu:

On November 17, 2017, the IRB reviewed the following submission:

Type of Review:	Modification/Update
Title of Study:	Biology and Physics Teacher Efficacy Beliefs: Instrument Validation by Two Science Teacher Groups
Investigator:	Philomena Agu
IRB ID:	MOD00000780
Funding/ Proposed Funding:	Name: Unfunded
Award ID:	None
Award Title:	
IND, IDE, or HDE:	None
Documents Reviewed:	• Email Script 10-17 updated.pdf, Category: Recruitment Materials; • HISD Approval Letter.pdf, Category: Letters of Cooperation / Permission; • Survey, Category: Study tools (ex: surveys, interview/focus group questions, data collection forms, etc.); • Protocol 11-17.pdf, Category: IRB Protocol; • Consent 10-17.pdf, Category: Recruitment Materials;
Review Category:	Exempt
Committee Name:	Not Applicable
IRB Coordinator:	Sandra Arntz

The IRB approved the following revision on November 17, 2017; the approval end date for the research study remains December 4, 2019.

Summary of approved modification(s):

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Added 200 high school science teachers from Houston Independent School District to the number of participants and modified recruitment method to include the teachers in the district. Attached approval letter from Houston Independent School District.to conduct research in the district.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

Sincerely,

Office of Research Policies, Compliance and Committees (ORPCC)
University of Houston, Division of Research
713 743 9204
cphs@central.uh.edu
http://www.uh.edu/research/compliance/irb-cphs/

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APPROVAL OF SUBMISSION

November 20, 2017

Philomena Agu

pagu@uh.edu

Dear Philomena Agu:

On November 20, 2017, the IRB reviewed the following submission:

Type of Review:	Modification/Update
Title of Study:	A Validation of Adapted Science Teaching Efficacy Belief Instrument by Certified Biology, Chemistry, and Physics Teachers
Investigator:	Philomena Agu
IRB ID:	MOD00000782
Funding/ Proposed Funding:	Name: Unfunded
Award ID:	None
Award Title:	
IND, IDE, or HDE:	None
Documents Reviewed:	• Protocol 11-17.pdf, Category: IRB Protocol; • HISD Approval Letter.pdf, Category: Letters of Cooperation / Permission;
Review Category:	Exempt
Committee Name:	Not Applicable
IRB Coordinator:	Sandra Arntz

The IRB approved the following revision on November 20, 2017; the approval end date for the research study remains June 8, 2021.

Summary of approved modification(s):

Added 200 high school science teachers from Houston Independent School District to the number of participants and modified recruitment method to include the teachers in the district. Attached approval letter from Houston Independent School District.to conduct research in the district.

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In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

Sincerely,

Office of Research Policies, Compliance and Committees (ORPCC)
University of Houston, Division of Research
713 743 9204
cphs@central.uh.edu
http://www.uh.edu/research/compliance/irb-cphs/

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APPROVAL OF SUBMISSION

November 27, 2017

Philomena Agu

pagu@uh.edu

Dear Philomena Agu:

On November 27, 2017, the IRB reviewed the following submission:

Type of Review:	Modification/Update
Title of Study:	A Validation of Adapted Science Teaching Efficacy Belief Instrument by Certified Biology, Chemistry, and Physics Teachers
Investigator:	Philomena Agu
IRB ID:	MOD00000789
Funding/ Proposed Funding:	Name: Unfunded
Award ID:	None
Award Title:	
IND, IDE, or HDE:	None
Documents Reviewed:	• Protocol 11-26 (1).pdf, Category: IRB Protocol;
Review Category:	Exempt
Committee Name:	Not Applicable
IRB Coordinator:	Sandra Arntz

The IRB approved the following revision on November 27, 2017; the approval end date for the research study remains June 8, 2021.

Summary of approved modification(s):

A deleted approved recruitment method, "The email address is usually accessible to the public. The investigator will recruit teachers by visiting school websites and obtaining the subject's email address," is restored as a recruitment method. A decision by the Principal Investigator to include the recruitment method was to reach out to more potential participants in Texas high schools because of a very low response rate from the currently active panel members.

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In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

Sincerely,

Office of Research Policies, Compliance and Committees (ORPCC)
University of Houston, Division of Research
713 743 9204
cphs@central.uh.edu
http://www.uh.edu/research/compliance/irb-cphs/