A Comparison of Teaching Efficacy Beliefs of Generalist and Subject-Specific Certified Biology Teachers

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Abstract

The No Child Left Behind act allows secondary science teachers to obtain certification in General Science and subject-specific fields. The Texas Examination of Educator Standard in General Science has low life science contents (30 percent) while the subject-specific exam is higher (75 percent). The state presumes both groups of teachers would teach biology with equal efficacy if candidates did not earn an undergraduate degree in biology or a related field. This study assessed the Personal Efficacy and Outcome Expectancy of the generalist and subject-specific certified teachers for 562 biology teachers in Texas public high schools using adapted Science Teaching Efficacy Belief Instrument. While controlling for undergraduate degree major and teaching experience, a hierarchical multiple regression analysis showed that subject-specific and General Science certifications did not yield significant differences. An undergraduate major in teaching subject, biological science, predicted a higher level of each sub-construct than a major in a different field.

I. Background and Context

The No Child Left Behind law permits states the flexibility to define certification requirement for their teacher candidates. The law also made provisions for science teachers to obtain certification in either the broad field of science (General Science) or in a particular science subject (Spring, 2011); New No Child Left Behind Flexibility: Highly Qualified Teachers, 2004). The criteria for screening teachers' subject matter knowledge through certification processes vary across states, although some have similar practices. A base requirement for high school science teachers is a possession of an undergraduate degree (Kaye, 2013). Some states require candidates to earn an undergraduate degree in a teaching subject in addition to a pass on a content knowledge test (Boyd, Goldhaber, Lankford, & Wyckoff, 2007). Others require prospective teachers to obtain an undergraduate major in any field and also pass 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 testing (Boyd, Goldhaber, Lankford, & Wyckoff, 2007). Texas is among the states which require an undergraduate degree from any field and a pass in a certification examination (Boyd et al., 2007; Initial Certification: Becoming a Classroom Teacher in Texas, Texas Education Agency). Usually, states issue an initial standard certificate to teachers who fulfilled most of the state requirements for certification and such teachers are often considered to be certified (Darling-Hammond, 2000; Laczko-Kerr & Berliner, 2002). The certified teachers in this study are those who hold an initial standard license.

II. Problem

In the early part of the 1990s, Texas would require prospective high school science teachers to take relevant college coursework to become certified in a teaching science subject. The state currently introduced subject-matter tests as part of certification requirements and offers tests in subject-specific science fields and General Science. Both exams are the primary means of verifying subject matter knowledge since candidates must not earn an undergraduate degree major in a teaching field. Life Science and biology are the subject-specific tests biology teacher candidates take. However, the state discontinued the biology competency exam in the early 2000s, but veteran teachers certified in biology still teach life science courses.

Currently, General Science (science 7-12) and Life Science competency tests are the two contents tests available to teachers aspiring to teach biology and other Life Science courses in public high schools. Both tests contain questions in four similar Life Science domains of cell structure and processes; heredity and evolution of life; diversity of life; and life interdependence and environmental systems. The observational difference is in the percentage concentration of questions from these domains. While the Generalist test contains only 30 percent of 140 multiple-choice questions, the Life Science examination includes 75 percent of 100 multiple-choice questions from these domains. This study made the following assumptions(a)candidates who took the Life Science test to become certified demonstrated more knowledge of Life Science contents by answering more questions (b) Life Science and Biology certified teachers have more knowledge of biology contents than General Science Certified teachers. Even though studies established an association between content knowledge and teacher efficacy (Newton, Leonard, Evans, & Eastburn, 2012), minimal studies have been conducted in certification and teacher efficacy. This study compared teacher efficacy (personal efficacy and outcome expectancy) of biology teachers certified in General Science and subject-specific science fields.

III. Theoretical Background

This study stemmed from the efficacy construct of social cognitive theorist Albert Bandura. According to Bandura (1977 & 1986), self-efficacy and outcome expectancy predict human behaviors, including choice of activities to perform, how much effort to put in doing work, and coping abilities in stressful situations. Generally, "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). That is, a person requires personal efficacy to perform a task efficaciously. Consequently, one would expect General Science and Life Science certified teachers to have firm beliefs in their ability to teach biology to students in public high school settings efficaciously. In an educational context, personal efficacy and outcome expectancy are termed teacher efficacy beliefs (Riggs & Enochs, 1990, p. 5). Due to the construct's specific nature, Riggs and Enochs (1990) developed Science Teaching Efficacy Beliefs Instrument (STEBI) specific for studies involving teaching science in elementary grades. Then, scholars adapted STEBI in studies involving efficacy beliefs of subject teachers. Similarly, HS-*STEBI*-bio (Agu & Ramsey, 2018) adapted from STEBI-chem (Rubeck, 1990) was used to measure the certified teachers' personal efficacy and outcome expectancy.

IV. Significance of the Study

Texas's state requires most students in public schools to pass the State of Texas Assessment of Academic Readiness end-of-course biology examination before earning a high school diploma (Texas Education Agency: Students Testing and Accountability, End-of-Course (EOC) Assessments, 2018). As a result, there is a need to pay attention to the biology teachers' efficacy beliefs to ensure that the state uses appropriate certification tests to select competent biology teachers. Besides, this study would guide policymakers in creating effective certification policies that would produce teachers with related content knowledge of biology to ensure equity in distributing highly qualified biology teachers across most classrooms in the state public schools. Since more affluent schools tend to draw highly qualified teachers than poor neighborhood schools, it is relevant to identify the most effective screening process for selecting highly qualified biology teachers since the subject contents in general science and life science vary 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 deficient licensure screen enables low-quality teachers. Since biology is a required course for high school graduation, privileged and disadvantaged students need highly qualified teachers. Thus, it is essential to identify and select a certification process that produces efficacious biology teachers.

Additionally, this study's results add to a rationale that could guide policymakers in retaining, adding, or deleting secondary science certification fields. The state discontinued two-subject specific certification fields, biology and physics. Since then, General Science has become the preferred certification field for most science teacher candidates, presumably due to employability opportunities. The General science credential qualifies a candidate to teach biology, chemistry, physics, and most other high school science electives. However, generalist teachers may be assigned subjects for which they have little academic preparation, and lack of subject matter knowledge may impact their sense of efficacy. Thus, this research provided empirical evidence on the effectiveness of generalist 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).

V. Review of the Literature

V. 1. Relationship among Teaching Efficacy Factors and Student Leaning Outcome

Bandura (1977) defined Personal 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). Both subconstructs predict human behaviors (Bandura,1986, 1997, 1977). As a result, researchers in education use efficacy construct to study teaching efficacy. Scholars discovered that low efficacious teachers usually doubt their ability to teach (Ashton & Webb, 1986), consider low achievers and students from low socioeconomic status unteachable, and fail to share responsibility for such students' failures (Ashton, Webb, & Doda, 1982). On the contrary, high efficacy teachers teach low achieving and economically disadvantaged students competently (Ashton, Webb, & Doda, 1982). In instructional behaviors, while the high efficacy teachers use more student-centered instruction that provides students with hands-on experience, promote their concept retention, and aid in concept attainment, the low efficacy teachers employ teacher-centered instructional approaches that do not promote learning but minimize students' behavior problems (Czerniak & Schriver, 1994). Besides, high efficacy teachers advance students' learning gains, although not in all measures (Angel & Moseley, 2010; Ashton & Webb, 1986; Hoy & Woolfolk, 1990; Czerniak & Schriver, 1994; Lumpe, Czerniak, Haney, & Beltyukova, 2012). In high school, Angel and Moseley (2010) used STEBI to measure personal efficacy and outcome expectancy of high school biology teachers and matched the teachers' efficacy belief scores to their students' achievement on a biology end-of-course examination. The student taught by teachers with high outcome expectancy scored significantly higher than the students who received instruction from teachers with low outcome expectancy. The personal efficacy did not yield a significant outcome. In a similar study with middle-grade students, personal efficacy was a significant and positive predictor of students' science achievement scores (Lumpe, Czerniak, Haney, and Beltyukova, 2012). In elementary grade, both personal science and outcome expectancy predicted students' science achievement significantly among fourth-grade students. Thus, scholars have used both personal efficacy and outcome expectancy to assess science teaching efficacy and learning.

In a different study, empirical evidence revealed that personal efficacy has social consequences (Wang, Hall, & Rahimi, 2015). The scholars reported 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 reported higher job satisfaction, lower burnout, and less frequent illness symptoms. The teachers' self-efficacy beliefs lead to job satisfaction (Caprara, Barbaranelli, Steca, and Malone (2006) and having job dissatisfaction is one of the most reported reasons why teachers quit teaching (Ingersoll, 2001). Also, "teachers' beliefs in their ability to use effective teaching strategies corresponded with a stronger intention to quit" (p. 12), suggesting that effective teachers could be quitting the profession and leaving the teachers with low efficacy behind.

In arguing the rationale for developing Science Teaching Efficacy Beliefs Instrument (STEBI), Enoch and Riggs (1990) asserted that an investigation of teacher beliefs is key to obtaining a "more complete understanding of teacher behaviors" (1990, p. 3). Teacher beliefs about a teaching subject primarily accounted for overall individual differences in teacher effectiveness (Cess-Newsome, 1999). Several researchers have sought ways to improve teacher efficacy beliefs and some studies that the types of science courses teachers took and the number of such college courses completed is related to teacher efficacy beliefs (Bergman & Morphew, 2015; Menon & Sadler, 2016; Morrell & Carroll, 2003; Schoon & Boone, 1998; Wenner, 1993). Bergman and Morphew (2015) discovered that preservice elementary teachers' self-efficacy and outcome expectancy increased after completing a semester of physical science course. Similarly, early childhood and elementary teachers positively changed their science teaching efficacy after taking 5-credit-hours of physical science courses (Menon and Sadler, 2016). 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. At the same time, research evidence supports that it is also essential for high school science teachers to have sufficient content knowledge in science (Sanders, Borko & Lockhard, 1993; Woolnough, 1994; Childs & McNicholl, 2007).

V. 2. Association between Subject Matter Knowledge and Teacher Effectiveness

Scholars are yet to find the most appropriate measure of teacher candidates' subject matter knowledge. Some studies have used a college degree in a teaching subject (Shulman, 1986, 1987; Woolnough, 1994; Ingersoll, 1999; Childs and McNicholl, 2007; Evans, 2011). Evans (2011) discovered that mathematics majors showed a significantly higher knowledge of mathematics contents than business and liberal arts majors, suggesting that scholars could use a type of undergraduate college major to assess a teacher candidate's subject matter knowledge. Other studies have used certification types to assess subject content knowledge (Sanders, Borko, & Lockhard, 1993; Tretter, Brown, Bush, Saderholm, & Holmes, 2013). Studies found that teachers certified in physics scored significantly higher in physical science assessment test than teachers who earned certification in biology or earth and space science and took the same test (Tretter, Brown, Bush, Saderholm, & Holmes, 2013).

This report implies that physics-certified teachers seemed to have higher content knowledge of physics materials than science teachers who do not possess physics certification but certified in other science areas. In the same study, teachers not certified in a science field scored lower than the biology or earth and space science certified teachers (Tretter, Brown, Bush, Saderholm, & Holmes, 2013), implying that teachers certified in science had more knowledge of physics than non-certified science teachers.

Some other measures of the subject (content) knowledge includes the type of college courses teachers in different grade levels took and tests scores (Evans, 2011; Kaye, 2013; Laczko-Kerr & Berliner, 2002; National Task Force on Teacher Education in Physics [T-TEP], 2010; Sadler & Sonnert, 2016; TEA, 2016; Tretter, Brown, Bush, Saderholm, & Holmes, 2013; Van Driel, Berry, & Meirink, 2014). It was reported that the 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, and primary grade teachers usually earn the least number of courses in the science fields (Tretter, Brown, Bush, Saderholm, & Holmes, 2013). With researchers having diverse viewpoints on assessing subject matter knowledge, it becomes difficult to have a threshold subject content knowledge required for effective science teaching. Nonetheless, most studies revealed that high content knowledgeable teachers exhibit desirable classroom practices which differ significantly from that widely used by teachers characterized as having low content knowledge (Childs and McNicholl, 2007; Newsome & Lederman, 2001; Osborne et al., 2003; Sanders, Borko & Lockhard, 1993; Trumper, 2006; Sadler & Sonnert, 2016; Shulman, 1986; Williams, Stanisstreet, Spall, Boyes & Dickson, 2003; Woolnough, 1994). Childs and McNicholl (2007) reported that teachers who taught within a subject of expertise use a more student-centered approach, similar to instructional methods used by teachers with high efficacy beliefs. On the contrary, teachers who taught science subjects outside their specialist field use more teacher-centered activities (Childs & McNicholl, 2007), thus sharing similar instructional approaches with low efficacy teachers. Koballa and Crawley (1985) discouraged teacher-centered methodologies because such methods cause elementary and secondary students to develop a negative attitude towards science and recommend a student-centered teaching approach. According to Gess-Newsome (2001), effective teaching methodologies are similar to those that characterize high content knowledge teachers.

At the same time, some studies fail to support an association between content knowledge and teacher effectiveness (Darling-Hammond, Holtzman, Gatlin and Heilig, 2005; Goldhaber & Brewer, 2000; Laczko-Kerr& Berliner, 2002; Newsome and Lederman; 2001; Sadler & Sonnert, 2016; Tretter et al., 2013; Van Driel, Berry, & Meirink, 2014). Goldhaber and Brewer (000) reported that teachers' possession of a subject-specific math degree significantly predicted the students' math score. Still, such specified knowledge does not affect science. It is noteworthy that Goldhaber and Brewer (2000) 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. The basics sciences split into different disciplines in high school, including biology, physics, and chemistry. Physics and chemistry (physical sciences) are pure natural science and mathematics-based fields (Brint et al., 2012); biology is a life science and is mostly non-mathematics based. The factors affecting students' outcomes in biology may not necessarily influence their achievement in physics and chemistry.

V. 3. Certification Exams and Association Teacher Effectiveness

Teacher certification status is a measure of teacher qualifications that combines subject-matter knowledge, teaching and learning (Darling-Hammond, 2000). Several studies have associated certification and teacher effectiveness in advancing academic achievement of students (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 (2000) discovered that teachers certified in science performed higher in a standardized test in science than students of uncertified science teachers. However, Goldhaber and Brewer did not report whether the teachers possessed a General Science certificate or a teaching license in a subject-specific science field. Nonetheless, other studies on the performance of elementary and middle school students taught by certified and uncertified teachers revealed similar outcomes (Darling-Hammond, 2000; Laczko-Kerr & Berliner, 2002; Darling-Hammond, Holtzman, Gatlin & Heilig, 2005; Cowan & Goldhaber, 2015). Laczko-Kerr and Berliner (2002) measured the influence of certification on standardized test scores in reading, math, and language arts of elementary and middle-grade students and discovered that the students taught by certified teachers outperformed students taught by uncertified teachers in all measures. In a similar study, Darling-Hammond et al. (2005) reported that teachers without certification slowed student progress over a year by half to one month in grade equivalent terms in achievement tests. Cowan and Goldhaber (2015) also obtained a positive relationship between teacher effectiveness and different varieties of standard certifications offered to elementary and middle-grade teachers. However, the teachers received their teaching license in diversified departments and not within a particular field.

Hence, the teaching Licensure Cowan and Goldhaber studied seemed different from General Science and subject-specific certification in this study: certificates issued to teachers in the same department who teach the same course.

In similar research, Clotfelter, Ladd, and Vigdor (2007) discovered that teachers certified through a more rigorous National Board Certification program were more effective than state-certified teachers, suggesting that certification rigor could impact the efficacy of certified teachers. This report seems to indicate that certified teachers could have different levels of effectiveness. In another study, scholars reported that the scores of math students taught by math-certified teachers increased significantly, but certification in biology did not affect the biology grade of biology students (Clotfelter, Ladd, & Vigdor, 2007). At the same time, this report seems to highlight the importance of subject-specific certification. Sanders, Borko, and Lockhard (1993) reported that teachers certified in the subject-specific field (biology, chemistry, earth science, and mathematics) taught like experts within their specialized subject but were incompetent in teaching other subjects outside their certification field. The issue is that the General Science certified teachers might not believe in their ability to teach the five courses making it necessary to study the generalist's efficacy in teaching biology.

It is essential to mention that not all studies support that possessing a standard teaching license is necessary for selecting qualified teachers (Goldhaber & Brewer, 2000; Kane, Rockoff & Staiger, 2007; Wiseman & Al-bakr, 2013)). According to Goldhaber and Brewer (2000), the students of teachers who hold emergency certification (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 hold a standard license. The school districts carefully screened the "teachers with emergency credentials for ability or content knowledge than those with standard certification" (p. 139). In a similar study, Kane, Rockoff, and Staiger (2007) observed that math and reading scores of elementary and middle-grade students whom certified teachers taught were just very slightly higher than the student of teachers taught by uncertified teachers. The scholars recommended that educational policymakers seek alternative ways of screening out less qualified teachers other than through certification processes.

The issue is that most empirical studies have not yet reached a consensus on the most effective criteria for assessing teacher candidates' content knowledge and ensuring that those with adequate subject matter knowledge are selected to become teachers. Some agreed on a candidate's certification performance (Clotfelter, Ladd & Vigdor, 2006; Clotfelter, Ladd, & Vigdor, 2007; Goldhaber, 2007; Goldhaber & Hansen, 2010). Goldhaber (2007) studied the impact of teacher performance on Praxis II curriculum and content licensure tests on elementary students' reading and math outcome and reported that the teachers who passed both subject and curriculum tests were more effective in advancing math and reading scores than those who failed the tests. When teachers who passed the subject test were grouped based on their scores, the teachers who performed at the top quintile were more effective than those who scored at the bottom quintile (Goldhaber, 2007). This report suggests that researchers could use teacher performance on certification subject test to screen for teacher effectiveness. The teachers who performed above average on licensure examination raised students' math scores while those who scored below average reduced their math achievement (Clotfelter, Ladd, & Vigdor, 2007). The teacher scores on licensure examination have consistently predicted the achievement outcome of students. The 5th-grade students of teachers with higher average test scores performed higher in math and reading achievement examination (Clotfelter, Ladd, & Vigdor, 2006). Goldhaber and Hansen (2010) investigated whether teacher scores on certification test could predict student learning outcome in math and reading and found that a pass in the licensure test was significantly related to an increase in the students' math grade, findings consistent with reports by Goldhaber (2007). However, the students' reading outcome did not improve, implying that a minimum score on a certification test may not be used to predict teacher effectiveness in improving student outcome across all subjects. Note that the minimum score to pass the TExES is the same for both General Science and subject-specific fields, and candidates are allowed five attempts to pass the test (About the TEXES Tests: Educator Certification Test Retake Policy Change, TEA, 2017). The problem is, does a pass in General Science has a different connotation of teacher effectiveness per a reference subject compared to a pass in subject-specific fields? Again, the purpose of this investigation is to measure the teaching efficacy of science teachers who obtained certification in General Science and subject-specific science field and teach biology.

It is relevant to mention that some empirical studies failed to associate certification examination with teacher effectiveness. Some argued that since licensure tests are not directly associated with student learning outcomes, such testing may not be a good measure of how well a teacher will perform in the classroom (Boyd, Goldhaber, Lankford, and Wyckoff, 2007, p. 59). Continuing the argument, teachers in a state with a testing requirement and the states without licensure testing have a similar academic background (Boyd, Goldhaber, Lankford, and Wyckoff, 2007). There was no evidence of teacher effectiveness in states with a testing requirement and those without certification by examination. Hence the argument was difficult to verify.

V. 4. Teaching Experience and Association with Teacher Effectiveness

Several studies supported that the number of years teachers spent in teaching has a relationship with teacher effectiveness (Cakiroglu, Capa-Aydin &Woolfolk Hoy, 2012; Child & McNicholl, 2007; Clotfelter, Ladd & Vigdor, 2007; Darling-Hammond, 2000; Shulman, 1987). Nonetheless, Darling-Hammond (2000) argued that "teacher effectiveness and their years of teaching are not always linear as the benefits of experience level off after about five years mainly if the veteran teachers do not engage in professional developments (p. 7). Other studies supported a nonlinear association between experience and teaching effectiveness (Clotfelter, Ladd, & Vigdor (2007). A few other studies believe that gain in teaching experience could extend beyond five years, with a peak occurring between 13 and 26 years with half of the experience gains occurring between the first one or two years of teaching (Clotfelter, Ladd, & Vigdor, 2007). To sum, the studies seemed to suggest that teaching experience help teachers to be more efficacious up to a specific time. Other studies reported that only teachers who began teaching with low efficacy grew in knowledge (Cakiroglu, Capa-Aydin & Woolfolk Hoy, 2012). This report suggests that experience could help low-ability teachers gain knowledge and may not influence teachers who began teaching with high confidence and ability. However, Child and McNicholl (2007) were surprised that experienced teachers and beginning teachers encountered similar challenges when each taught a science subject outside their field of specialism. A report that could suggest teacher competency and experience varies with the nature of the teaching subject. Thus, studies have not established if experienced and beginning teachers will always encounter similar challenges in most science teaching situations.

V. 5. Research Question

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

VI. Methodology

VI.I. Sample and Data Collection

Participants were in-service biology teachers in Texas public high schools. Qualtrics, a survey platform, distributed the survey online to 11,665 science teachers in the fall of the 2017-2018 academic year. The Qualtrics 'skip logic' feature was used to exclude non-biology 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?

The participants who answered 'no' to the 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. Only data from the biology group were analyzed and reported, although data were collected from the three core science teachers. Data were imported into Statistical Package for the Social Sciences (SPSS) 25.0 for analysis. A total of 562 biology teachers participated in the study, with 177 males and 365 females reporting their gender. Table 1 shows the demographics of the study participants.

VI.2. Analytical Techniques

First, the validity of the adapted HS-STEBI-bio was examined using Principal Component Analysis. The results showed that 13 variables measure Personal Efficacy and 10 items define Outcome Expectancy. Second, the internal consistency reliability of both subscales was conducted using Cronbach's alpha. Each subscale recorded overall alpha of .81. Afterwards, a hierarchical multiple regression analysis was conducted to compare Personal Efficacy and Outcome Expectancy of General Science and subject-specific teachers while controlling for their undergraduate degree major and teaching experience.

VII. Analysis and Results

VII.1. Data Screening

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. The cases with outliers were removed. The tests were conducted by selecting "exclude cases listwise" option to ensure each participant had scores for both PE and OE variables. The dependent variables were screened further for normality using skewness and kurtosis tests. The skewness results, 1.23 and .41 for Personal Efficacy and Outcome Expectancy respectively indicated a normal distribution. Similarly, the kurtosis result, .80 and 1.61 supported normality for the two dependent variables.

VII.2. 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. Then, the groups were divided into four categories: life science, biology, general science, and others. The groups that belong to each category are displayed in Table 2. This study assumed that a participant who took the Texas Examination of Educator Standards (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. Hence, a teacher certified in life science only or life science with any other type of certification was coded "life science." Also, a participant was assigned "life science" code if they possessed life science and biology certification. The decision was made because the life science test's composition is known, and life science certification is currently available to teachers and thus more useful in this study. The biology certification was discontinued, and information about the nature and composition of the test was unavailable. The biology certification and life science certification were not combined because (a)teachers earned certification in both life science and biology, indicating the two tests may be different (b) the biology and life science certifications categories recorded significant negative correlation in regression analysis, $r = -.40$, $p < .001$ (see Table 5), 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 "General Science" code if that teacher obtained certification in General Science only with no biology or life science. The code "other" was assigned to a teacher with a non-science certification. Table 3 shows descriptive statistics of participants in each certification group.

VII.3. Coding Teaching Experience and Undergraduate Major

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). Similarly, the college majors 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).

VII.4. Regression Analysis

First, the predictors, certification, undergraduate degree major, and teaching experience were dummy coded before multiple regression analysis as displayed in Table 4. Then, the PE and OE items were each summed to obtain a general score. With alpha equal to .05, a two-stage hierarchical multiple-regression analysis was used to predict Personal Efficacy. In the first block, 0 to 5 years, 6 to 10 years, 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 5 while the results of the hierarchical multiple regression analysis are shown in Table 6. The three control variables are statistically significant predictors of Personal Efficacy, $F(3, 508) = 11.49$, $p < .001$, $R^2 = .06$. 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 than teaching experience of more than 10 years. Though not statistically significant, a biological science undergraduate degree major predicted higher level of Personal Efficacy than a major in non-biological or physical science.

When the predictors of interest, life science and biology certification were entered simultaneously in the second block, the covariates, 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, general science certification and subject-specific certification (life science and biology) were non-significant predictors of Personal Efficacy. The covariates, teaching experience 0 to 5 and 6 to 10 were significant predictors of PE. The procedure was repeated with OE. However, the model was non-significant. The results are shown in Table 6.

VII.1. Conclusion

The descriptive statistics revealed that most participants obtained certification in General Science, a finding supported by Ramsay (2013, 2015, 2016), who reported that science teacher candidates prefer General Science certification. However, the hierarchical multiple regression analysis results revealed that certification showed no significant effect on the biology teachers' personal efficacy or outcome expectancy. The present findings support previous work (Croninger, Rice, Rathbun, & Nishio, 2007; Goldhaber & Brewer, 2000; Kane, Rockoff, & Staiger, 2008, Wiseman & Al-bakr, 2013) documenting that certification does not influence teacher efficacy beliefs.

Instead, the control variable, an undergraduate major in a teaching subject (biological science), predicted a higher level of personal efficacy and outcome expectancy than an 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.

Contrary to expectations, the hierarchical multiple regression results 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, the scholars recommended that educational policymakers 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 general teachers obtain at least a minor in all five teaching subjects, a practice that was in place in Texas in the early 1990s before certification by examination.

Additionally, certification only did not significantly contribute to the prediction model, suggesting variables other than certification could influence the teachers' belief in their ability to teach biology effectively to the students and their belief that effective instruction will lead to students' learning gains. Also, results showed that Biology certification and an undergraduate degree in biological science were positively correlated. However, 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 was a consistent and positive predictor of student achievement. A suggestion would have been to explore the influence of having both a college major in biological science and biology certification on personal efficacy.

Further, teaching experience covariates recorded unexpected results. The beginning 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 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 of 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 not engaging in continuous learning opportunities.

Implication

With the confounding variables in the regression model, the General Science and subject-specific certification did not affect teacher efficacy beliefs. As a result, certification alone could not be used to measure the biology teachers' teaching efficacy beliefs. Instead, the control variables, teaching experience (0 to 5 years and 6 to 10 years) were predictors implying that variables other than certification are responsible for teacher efficacy beliefs. This study could not examine these variables because the regression model accounted for less than ten percent of the variance, and more than 90 percent of the variance was still unexplained. Also, the majority of the biology teachers earned certification in General Science only or General Science with other types of secondary science certification, and the credential qualifies a teacher to teach biology and most high school science courses, it will be necessary to conduct a follow-up study on the effectiveness of the generalist with interviews and observations. A second method of verifying generalist competency is to review students' scores in the State of Texas Assessment of Academic Readiness (STAAR) biology end-of-course exam and compare the performance of students taught by generalist and the performance of students taught by subject-specific teachers.

This study also revealed that most biology teachers acquired different types of science certifications signaling that in-service biology teachers earned additional certifications while teaching and that general science certificate is dominant. Usually, initial screening for the standard license could include assessing 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 received General Science certificate 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 and 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 the hierarchical regression analysis showed that an undergraduate major in biological science predicted higher levels of personal efficacy and outcome expectancy in teaching biology than an undergraduate major in a non-physical science or non-biological science. Based on this investigation results, policymakers need to re-examine the practice of "adding additional certification by examination." There is a demonstrable benefit of possessing an undergraduate major in a teaching subject. In place of taking a test, in-service teachers could be required to earn a minor in each of the teaching fields covered by general science test (biology, chemistry, physics, earth, and space science). Moreover, since science teachers' candidates prefer certification in general science (a certificate that qualifies teachers to teach most science courses), a subject-specific certification could gradually be extinguished. The state already discontinued certification in biology and physics. Hence, is it necessary to continue to conduct empirical studies on the effectiveness of general-science certified teachers.

Limitation

Since teachers earned more than one type of certification, including General Science and subject-specific certificates, teachers earning multiple certifications make it difficult to distinctly study the effect of general science and subject-specific certifications on biology teachers' efficacy beliefs. By their nature, survey methodologies produce subjective data. The validity of the results is, therefore, dependent on the participants providing honest and accurate responses.

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Appendix

Table 1

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
School Location		
Urban	162	29.9
Suburban	239	44.1
Rural	141	26.0

Table 2
Certification Codes and Teachers' Certifications

Certification Categories	Certification Groups
Life Science	
	Life Science only
	Life Science and General Science
	Life Science and Biology
	Life Science, General Science, and Biology
	Life Science and Physical Science (Chemistry, Physics or Physical Science
	Life Science, General Science, Biology, and Physical Science
	Life Science, Biology, and Physical Science
	Life Science, General Science, and Physical science
Biology	
	Biology only
	Biology and General Science
	Biology and Physical Sciences (Chemistry, Physics or Physical Science)
	Biology, General Science, and Physical Science
General **Science**	
	General Science only
Other	
	None-Science

Table3
Descriptive Statistics of Certification Groups

Certifications	Frequency	Percent
General Science Only	223	41.3
Life Science Only	128	23.7
Life science General Science	42	7.8
Life Science and Biology	29	5.4
Life Science, General Science, and Biology	5	.9
Life Science and Physical Science	8	1.5
Life Science, General Science, Biology, and Physical Science	4	.7
Life Science, Biology, and Physical Science	6	1.1
Life Science, General Science, and Physical Science	2	.4
Biology Only	54	10.0
Biology and General Science	19	3.5
Biology and Physical Science (chemistry, physical science or physics)	10	1.9
Biology, General Science, and Physical Science (chemistry, physical science or physics)	9	1.7
Non-Science	1	.2

N = 540

Table 4
Dummy Code Certification and Teaching Experience

	Life science	Biology
Life Science	1	0
Biology	0	1
General 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

Table 5

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 6

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 includes predictors from step one. ***$p< .001$. **$p< .01$