STEM EDUCATORS' PREPAREDNESS FOR ENGLISH LANGUAGE LEARNERS IN THE

UNITED STATES

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ABSTRACT

In the United States STEM (Science, Technology, Engineering, and Mathematics) education is increasingly being promoted as a key component of preparing students for the reality of an increasingly technology infused society and workforce. As the population of students classified as English Language Learners (ELLs) continues to grow across the United States the need for STEM educators to be prepared to effectively educate these students is of increasing concern. The task of preparing this group of learners to succeed in a STEM-infused society is a joint effort between specialized linguistic courses in the K-12 education system as well as the STEM educators outside of these specialized courses. As such, focus on creating policy and preparation models for STEM teachers to acquire the necessary skills to effectively serve the ELL population needs to be rooted in targeted analysis of the connections between STEM educators and ELLs.

This dissertation is comprised of two exploratory research studies that examine STEM teachers' preparedness to educate ELLs using secondary analysis of the 2007-2008 and 2011-2012 School and Staffing Survey Teacher Questionnaire (SASS TQ) datasets. The first study focuses on national and regional analysis of how STEM teachers' degrees, state-level certification areas, and professional development participation reflect potential indicators of preparedness to educate ELLs. Concurrently, this study examines ELL participation in STEM courses nationally and regionally through the percentage of STEM teachers who had ELLs in their overall service loads of students as well as the average number of ELLs in those service loads. Quantitative analysis showed drastic differences between regions as well as differences in ELL participation and teacher credentialing between the STEM disciplines. The second study utilizes both the 2007-2008 and 2011-2012 SASS TQ datasets to make comparisons in STEM educators credentialing and ELL participation in STEM courses over the four year time span between the datasets. National analysis of ELL participation in STEM courses showed that in all of the STEM disciplines the percentage of teachers who had ELLs in their total service loads of students increased. The growth of ELL participation differed across disciplines and across regions, however, nationally by 2012 over half of all STEM educators reported having ELLs in their service loads of students. Despite the growing participation of ELLs in STEM courses, the rates of STEM teachers' participation in ELL specific professional development activities largely stagnated over the four year span. The findings of these studies provide valuable information to frame discussions of STEM teachers' preparedness to meet the needs of a growing population of ELLs.

Keywords: STEM Education, School and Staffing Survey Teacher Questionnaire, English Language Learners

GENERAL AUDIENCE ABSTRACT

The growing number of students classified as English Language Learners (ELLs) in the public school system within the United States has increased educational researchers' attention on this unique group of learners. Students classified as ELL have specific language needs that must be addressed in unison with their education in other disciplines. Within the disciplines of Science, Technology, Engineering, and Mathematics (STEM) Education there has been a lack of national analysis of how teachers are prepared to meet the needs of this growing population of students.

This dissertation is comprised of two complimentary studies that use a national dataset to analyze potential indicators of STEM teachers' preparedness to work with students classified as ELLs by examining their credentials related to educating ELLs. The first of the two studies use regional and national analysis to examine how the rates of STEM teacher credentialing related to ELLs differs among the STEM disciplines and across the United States. The second study used multiple datasets to analyze changes across a four year time span in the rates of ELL participation in STEM teachers' courses as well as STEM teachers credentialing related to ELLs.

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Chapter 1. Introduction to the Dissertation

Background

Over the past decade and prior schools in the United States have become more linguistically diverse, and this demographic shift has generated a sense of urgency around helping teachers support the academic success of language minority students (Molle, 2013). The population of English Language Learners (ELLs) varies widely on aspects such as native language, socioeconomic status, parents' educational backgrounds, level of English proficiency when entering a school, and race (Capps, Fix, Murry, Ost, Passel, Herwantoro, 2005; Garcia, & Cuellar, 2006). "English learner (EL) students constitute nine percent of all public school students and are enrolled in nearly three out of every four public schools" (U.S. DOE, & U.S.DOJ, 2015, p.1). Research indicates a growing population English Language Learners in the K-12 education system (NCES, 2016). "The fastest-growing student population in U.S. schools today is children of immigrants, half of whom do not speak English fluently and are thus labeled English learners" (Calderón, Slavin, & Sánchez, 2011, p.103). The number of Language Minority (LM) students is projected to constitute 40 percent of the school-age population by the 2030s, and "most U.S. schools are currently under-educating this student group" (Thomas & Collier, 2001, p.1).

It is important to note that the terms ELL. EL, and LEP are often used interchangeably in the literature surrounding this population (Calderón, Slavin, & Sánchez, 2011; Callahan, Wilkinson, & Muller, 2010; García, Arias, Harris Murri, & Serna, 2010; National Center for Educational Statistics, 2011; Menken, & Antunez, 2001). Although often in literature the terms LEP and ELL are used interchangeably, when the two terms are differentiated LEP students are described as a subset of the ELL population.

Generally, students are counted within the LEP group only as long as they are considered to lack enough proficiency in English to participate in grade-level classes without specialized support. When ELLs have gained the proficiency in the English language needed to participate in grade-level classes, they lose their LEP designation and are required to participate in the mainstream classroom without specialized support" (Francis, Rivera, Lesaux, Kieffer, & Rivera, 2006, p.3)

This more specific classification of LEP students explains that the subcategory of ELLs that are referred to as LEP are differentiated by their scores on the state approved test of English Language Proficiency (ELP). When the two terms are separated, the term LEP is used to refer to a subgroup of the ELL population that has been identified through state approved English Language Proficiency (ELP) assessment to need additional instruction in the acquisition and use of the English language to be able to participate fully in classes that are taught in English only without specialized support. Whether used interchangeably or differentiated between, the term ELL can still be understood as the overarching category that encompasses the two. Within the context of the School and Staffing Survey Teacher Questionnaire the term limited-English proficiency (LEP) and English-Language Learner (ELL) are used interchangeably to represent students "whose native or dominant language is other than English and who have sufficient difficulty speaking, reading, writing, or understanding the English language as to deny them the opportunity to learn successfully in an English-speaking-only classroom"(National Center for Educational Statistics, 2011, p.10).

With the growth of the ELL population there is a related concern about teacher preparedness to meet the learning needs of these students (DelliCarpini & Alonso, 2014). When discussing teachers of English Language Learners it is important to take into account that there is currently a shortage of English as a Second Language (ESL) teachers (Ballantyne, Sanderman, Levy, 2007; TESOL International Association, 2013; U.S. Department of Education, National

Center for Education Statistics, 1997). The professional association for Teacher of English to Speakers of Other Languages (TESOL) stated, "…the number of ESL and bilingual specialist has not kept pace with growth in ELL population, resulting in a limited workforce" (2013, p.5). While the role of ESL teachers is still critical to the success of ELLs, an increasing number of non-ESL teachers are being required to serve the needs of ELLs in their classroom and incorporate language learning (Hiatt, 2016; Staehr Fenner & Kuhlman, 2012). Content-based language instruction has typically been taught by language specialist, including ESL and ESOL (English for Speakers of Other Languages) teachers, however, due to the inadequate content knowledge of ESL and ESOL teachers, the success of this approach has been limited (Lee, Quinn, & Valdés, 2013, p.228). Due to the fact that language specialist, including teachers of ELL specific courses, often lack the extensive knowledge of the discipline specific content to adequately prepare ELLs to succeed in their content classes, it is recommended that content teachers incorporate language learning techniques into their courses in order to support ELLs (Lee, Quinn, & Valdés, 2013, p.228). The combination of a lack of ESL teachers, and a lack of the content knowledge needed to adequately instruct ELLs in content language from existing ESL teachers, adds momentum to the push for core academic teachers to modify instruction for ELLs. Research on this topic is increasingly advocating for all teachers, not just language specialist, to develop an understanding of how to most effectively teach the ELL students that are present in their classes (Hiatt, 2016; Lee, Quinn, & Valdés, 2013; Staehr Fenner, & Kuhlman, 2012). "In many cases, a general education teacher who knows the content and pedagogy to teach to the grade level standards will also need specific knowledge and skills to help ELLs access the curricula" (Samson, & Collins, 2012, p.2). The growing focus on general education

teachers' ability to effectively meet the needs of ELLs has been amplified by the rapid growth of this population of students.

ELL growth projections suggest a continued swelling in the numbers of ELLs beyond states that have been experiencing this phenomenon for years and into those that are just now noticing this demographic shift (Cheung, & Slavin, 2012; National Clearinghouse on English Language Acquisition, 2010; Pereira & de Oliveira, 2015). Figure 1 shows a map of the percent of ELLs by state. This graphic displays the wide variation of the densities of ELL population across the nation.

Figure 1. Percentage of Public School Students who were English Language Learners, by State: School year 2013–14
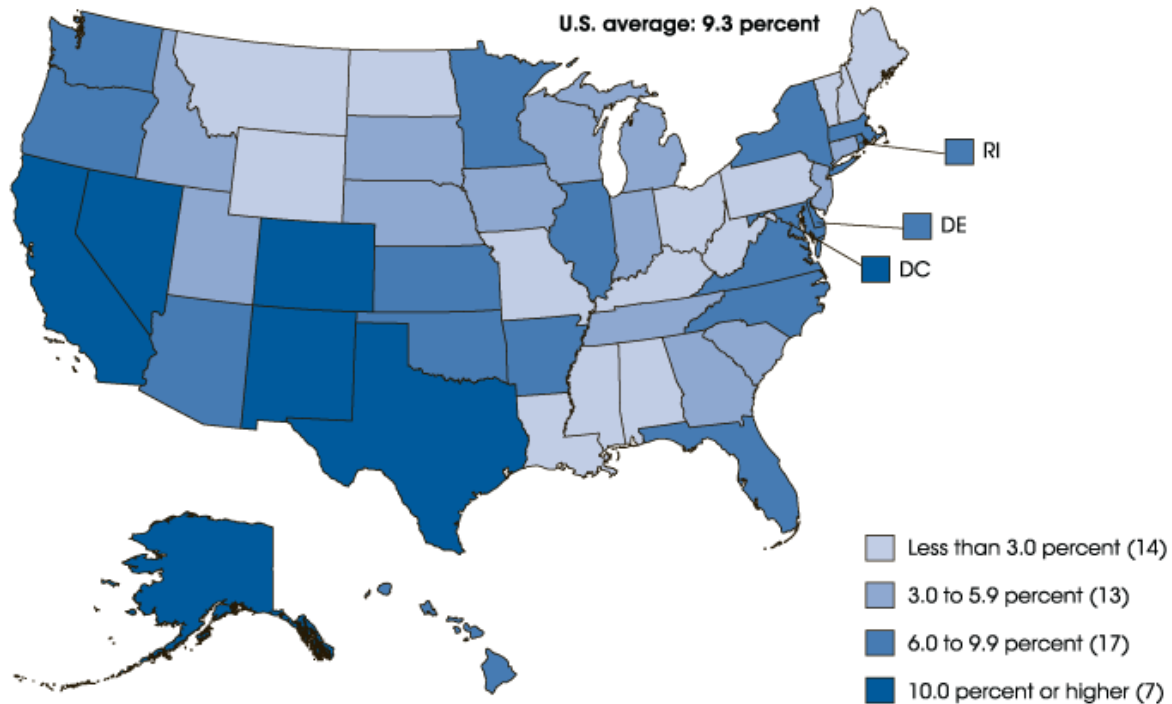
NOTE: Categorization based on unrounded percentages.
Figure 1. Percentage of Public School Students who were English Language Learners, by State. Reproduced from "The Condition of Education 2016" by NCES,& U.S.DOE., 2016.

According to a report from the National Center for Educational Statistics, in 2013-2014 West Virginia had the lowest percentage of ELLs in their public schools in the nation at an average of 0.7 percent; comparatively California had the highest with an average of 22.7 percent of the public school population being classified as ELL (National Center for Educational Statistics, 2015, p.1). The diversity of the distribution of ELLs makes addressing this issue from a federal level difficult.

> "Although the federal government requires districts to provide services to English learners, it offers states no policies to follow in identifying, assessing, placing, or instructing them. States, therefore, vary widely in the policies and practices by which they identify and assess English learners for placing within and exiting from instructional programs" (Calderón, Slavin, & Sánchez, 2011, p.104).

The uneven distribution of ELL students across the nation may explain the variation in state procedures involving ELLs. Most states utilize a definition of LEP that fits the needs of that specific community or use a simplified version of the federal definition (Hopstock, Bucaro, Fleischman, Zehler, Eu, 1993; Zehler, et al., 2003b). Furthermore, most state licensing requirements for teachers only make vague references to a teacher's ability to instruct ELLs, and over a quarter of states make no mention of ELLs at all in their licensing requirements (Ballantyne, Sanderman, & Levy, 2007, p.4).

Throughout the field of research on teacher training and preparedness, researchers seem to agree that teachers who do not hold bilingual or ESL certification are not well prepared to meet the needs of ELLs (Alexander, Heaviside & Farris, 1999; Ballantyne, Sanderman, & Levy, 2007; Karabenick, & Clemens Noda, 2004; Menken, & Atunez, 2001; Reeves, 2006; U.S. Department of Education NCES, 1997, 2001; Zehler et al., 2003a). This situation is of particular concern as general education teachers are being encouraged to adapt their practices to meet the

needs of ELLs in their classes. Additional research displays that many teachers may have fundamental misunderstandings or confusion about how long it takes for a student to acquire a new language, how speaking a language other than English at home impacts a student's learning of English, and the correlation between speaking ability in English and English comprehension (Ballantyne, Sanderman, & Levy, 2007; Karabenick, & Clemens Noda, 2004; Reeves, 2006). Research indicates oral proficiency takes 3 to 5 years to develop, and academic English proficiency can take 4 to 7 years" (Hakuta, Butler, & Witt, 2000). The duration of language acquisition indicates that ELLs will need to learn both corse content and language skills concurrently over the duration of several years if they are to keep pace academically. However, "teachers often lack the knowledge and the institutional support needed to address the complex educational needs of ELLs" (Lee, 2005, p.492).

Researchers have also noted that the issues surrounding the education of ELLs also extend to the policies that guide teachers' practices. Samson and Collins (2012) reported, "in our review of the research, we identified oral language development, academic language, and cultural diversity as critical bodies of knowledge and skill areas for all teachers of ELLs that were noticeably absent in the areas of policy and practice" (p.20). It is not uncommon for teachers to lack the institutional support and knowledge necessary for addressing the needs of ELLs (Lee, 2005, p.492). Outside the ESL classroom, ELLs spend much of their time in general education courses with teachers who are unprepared to effectively work with them (Calderón, Slavin, & Sánchez, 2011, p.103). Furthermore, teacher preparation is lagging behind the changing needs of the student body. In a large-scale study investigating teacher preparation in 417 institutions, only one-sixth of the teacher preparation programs required coursework specific to ELLs for mainstream teachers (Menken & Antunez, 2001). As the population of ELLs has

risen, it has become clear that teachers are not well prepared to meet the needs of this demographic reality (García, Arias, Harris, & Serna, 2010, p.135). Janzen (2008) reference data from the School and Staffing Survey stating, "A recent national survey determined that a high proportion of teachers, 41%, have ELLs in their classes, but only 12.5% of those teachers had had 8 or more hours of training in the previous 3 years on how to assist them" (p.1011). Beyond researchers displaying concerns about teachers' preparedness to meet the needs of ELLs, teachers themselves often feel ill-equipped for this challenge (Ballantyne, Sanderman, & Levy, 2007). In 2001 the NCES survey reported that only 27% of teachers felt that they were "very well prepared" to meet the needs of ELLs, and 12% of teachers reported that they were "not at all prepared" (U.S. Department of Education, NCES, 2001, p.33). In a survey of over 1,400 teachers, 26% of teachers indicated that they "very much needed", and 31% indicated that they "somewhat needed" more information to work effectively with ELLS (Alexander, Heaviside & Farris, 1999, p.10). A study conducted with 279 teachers found that over 80% of teachers believed that they did not have adequate training to work effectively with ELLs, and similarly 53% wanted more preparation (Reeves, 2006, p.136).

Educational reforms focused on STEM disciplines and initiatives have also garnered national focus in recent years. The term STEM has been in use in the field of education since it was introduced by the National Science Foundation (NSF) in 2001 (Marrero, Gunning, & Germain-Williams, 2014; Sanders, 2009). In some cases the term STEM education is used to discuss the four separate educational disciplines of Science, Technology, Engineering, and Mathematics (Bybee, 2010; Marrero, Gunning, & Germain-Williams, 2014; Morrison, & Bartlett, 2009). In other circumstances the term STEM education is used to stress the integration between these fields of study (Breiner, Harkness, Johnson, & Koehler, 2012; Marrero, Gunning,

& Germain-Williams, 2014; Morrison, & Bartlett, 2009; Sanders, 2009). Research involving both STEM education and ELLs is still an emerging field and much of the literature is still rooted in just one of the separate STEM disciplines. The field of K-12 Science education advocates for diverse populations to enter into STEM workforces and has undergone STEM related reform through the Next Generation Science Standards (NGSS Lead States, & National Academy of Sciences, 2013); yet researchers criticize Science educators lack of preparedness to effectively work with ELLs (Lee, 2005; Lee, Quinn, & Valdés, 2013). In the field of Technology education, research indicates that despite having a larger average number of ELLs in their classes than Math or Science teachers, Technology educators are participating in less professional development related to teaching ELLs than Math or Science teachers on average (Ernst, & Williams, 2014a; Ernst, & Williams, 2014b; Li, Ernst, & Williams, 2015; Williams, Ernst, & Kaui, 2015). Mathematics education faces a unique problem in addressing the needs of ELLs. "Math is a somewhat under researched discipline, perhaps because of a misguided belief that math is less difficult for ELLs because it is based on a language of numbers" (Janzen, 2008, p.1017). Despite the universality of the number system, the challenges ELLs face in mathematics classes and the lack of attention on this group of learners has been noted throughout literature on K-12 Math education (DelliCarpini & Alonso, 2014; Freeman, 2012; Janzen, 2008; NAEP, 2011; Menkin, & Antunez, 2001). DelliCarpini and Alonso (2014) commented on the relationship between ELLs and K-12 STEM education stating,

> Given the achievement gap that exists between ELLs and their native-speaking counterparts in STEM subjects, as well as the growing numbers of ELLs in US schools, this becomes a critical issue, as academic success for these students depends on the effectiveness of instruction they receive not only in English as a Second Language classes (ESL), but in mainstream classrooms as well (p.155).

As academic trends continue to stress the importance of students' success in the STEM disciplines it is becoming increasingly important to put focus on the needs of ELL populations in these fields of study (Lee, 2005; Janzen, 2008). Research on this topic is often focused on specific disciplines. Yet, amongst these discipline specific investigations there is a reoccurring trend of limited research on the intersection of course content and linguistics for ELLs in STEM courses (DelliCarpini & Alonso, 2014; Lee, 2005). As the nation turns its focus toward preparing the next generation to fill positions in STEM careers there is a need for further research that investigates and compares teacher preparedness for working with ELLs between all of the STEM disciplines.

There is an ongoing push for all teachers and policymakers to familiarize themselves with the unique demands of education ELLs (Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997). However, despite the increased demands on teachers to meet the needs of this growing population of English learners "there still are not enough studies exploring what works with English learners" (August, & Shanahan, 2010, p.344). As pointed out by DelliCarpini and Alonso, "little research exists on effective ways to prepare secondary Mathematics and Science teachers to work with English Language Learners in mainstream Mathematics and Science classrooms" (2014, p.155). In alignment with DelliCarpini and Alonso's research, Samson and Collins stated, "Currently, at the various stages of teacher preparation, certification, and evaluation, there is insufficient information on what teachers should know about teaching ELLs" (2012, p.8). Research into ELLs in Science education is still a new and developing field (Lee, 2005). The field of K-12 STEM Education has a need for more large-scale, national-level, investigations into teacher credentialing to meet the needs of English Language Learners (DelliCarpini & Alonso, 2014; Lee, 2005). This apparent absence of widespread, evidence-

based, effective practices for mainstream teachers working with ELLs further complicates the issue of how best to prepare teachers to work with ELLs.

Despite the focus in research on the need for general educators to adapt to the growing population of ELLs, the methods of building teachers' competency in this area also falls under criticism. In a research synthesis conducted by Knight and Wiseman (2006), the authors found very few studies that analyzed the effectiveness of professional development programs for teachers of ELLs. Research on teacher preparation initiatives for linguistic diversity is still an immerging field, with few studies analytically measuring outcomes for teachers and even fewer measuring student outcomes (Bunch, 2013, p.308). Researchers also call for more rigorous evaluation and documentation of professional development initiatives that focus on developing teacher knowledge and skills in promoting the learning of academic English with ELLs (DiCerbo, Anstrom, Baker, & Rivera, 2014, p.475). Furthermore, research on what techniques and instructional strategies work best for ELLs continues to be limited (August, & Shanahan, 2010; DelliCarpini, & Alonso, 2014; Samson, & Collins, 2012).

For students entering into a K-12 education system that utilizes English as the language of instruction, speaking a home language other than English can have academic and social repercussions. An immigrant's perception of the overall valence of a receiving society and the opportunity structure available in the receiving society is referred to in sociological literature as the "context of reception" (Portes, & Rumbaut, 2001; Schwartz, et al., 2014). Characteristics of a negative context of reception include social tension, ostracism, and a lack of opportunity; whereas a positive context of reception would foster a belief in one's ability to success in spite of adversities (Schwartz, et al., 2014, p.2). An educational system that fails to meet the needs of diverse learners contributes to a negative context of reception and a perception of reduced

opportunities in the labor market beyond school (Portes, & Böröcz, 1989; Portes, & Rumbaut, 2014). Preparing teachers to meet the needs of ELLs involves building new skills, understandings, and awareness of a diverse student body. Research relating to the professional development of teachers for cultural awareness expresses the necessity of addressing previously held negative beliefs and ideas about culturally diverse populations and defusing resistance to building new conceptions as an essential part of improvement (Causey, Thomas, Armento, 2000; Nelson, Guerra, 2014). Causey, Thomas, and Armento (2000) explain that the task of influencing attitudes toward diversity can be difficult due to the persistence of teachers' prior knowledge and beliefs about diverse populations (p.33). Other researchers have revealed that negative beliefs about diverse students can also lead to lower expectations from teachers (Nelson, Guerra, 2014, p.71). When working with linguistically diverse learners, literature indicates that teachers should have experiences with language diversity, have a positive attitude towards linguistic diversity, develop knowledge about how students' acquire a second language, develop skills for simultaneously promoting content and language learning in the classroom, and gain knowledge about their diverse students' backgrounds, experiences, and cultural norms (Markos, 2012, pp.42-43).

Overview of the Dissertation

Due to the growing number of ELLs in the K-12 education system in the United States there is a need for emphasis on the education of this unique learner group. As such, research that assess the current levels of preparation and credentialing teachers are receiving to guide their instruction of ELLs is in high demand. This dissertation is organized into two complimentary research studies investigating the relationship between K-12 STEM education teachers and ELLs. The first study focuses on the current state of this relationship across the nation and trends

within and among regions. This investigation will include STEM educators' ELL service loads, and ELL specific credentials.

The second study compares national and regional changes in ELL populations across a span of time as well as STEM teachers' ELL specific credentialing over time. Both studies utilize secondary analysis of the national restricted dataset of the 2007-2008 and 2011-2012 School and Staffing Survey Teacher Questionnaire (SASS-TQ) to make investigations into national trends in STEM education teachers working with ELLs.

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Chapter 2. Manuscript One

STEM Educators' Preparedness for English Language Learners

Keith Besterman

Abstract

Background

National growth of the population of English Language Learners (ELLs) in the K-12 education system has ignited discussions regarding teachers' ability to meet the need of these learners outside of specialized linguistic courses. Concurrently, K-12 STEM education has been the focus of educational reforms as schools attempt to keep pace with an increasingly STEM-based job market and technology infused society. Researchers have stated that it is increasingly necessary for teachers in the STEM disciplines to familiarize themselves with the educational needs of their ELL students (DelliCarpini & Alonso, 2014). Literature on this topic has shown that teachers do not feel well prepared to meet the needs of ELLs (U.S. Department of Education, NCES, 2001) and that they often lack the professional development opportunities to develop these necessary skills (August, & Shanahan, 2010; Ballantyne, Sanderman, & Levy, 2007; Janzen, 2008). However, analysis of STEM teachers' level of preparation in regards to ELLs, their participation in ELL specific professional development activities, and the level of inclusion of ELLs in STEM courses has not been explored thoroughly nationally and regionally.

Results

The national restricted access dataset of the 2011-2012 School and Staffing Survey (SASS) Teacher Questionnaire (TQ) was used to collect and analyze data regarding STEM teachers' credentialing related to ELLs, participation in ELL specific professional development activities, and rates of ELL participation in STEM courses. The results from this analysis were compared between the separate STEM disciplines of Science, Mathematics, and Technology education nationally as well as regionally.

Conclusions

The findings of this study indicated that nationally, in all of the STEM disciplines, more than half of teachers indicated having ELLs in their overall service loads of students. Nationally less than a quarter of STEM teachers in any discipline participated in ELL specific professional development activities in the last year, yet vast differences arise in regional analysis. Regions with higher rates of ELL participation in STEM courses also showed higher rates of ELL specific professional development participation.

Keywords

STEM education, School and Staffing Survey Teacher Questionnaire, English Language Learners

Background

Ongoing growth of the English Language Learner (ELL) population within the K-12 educational environment in the United States has led to increased attention on this unique population of learners (NCES, 2016). "The fastest-growing student population in U.S. schools today is children of immigrants, half of whom do not speak English fluently and are thus labeled English learners" (Calderón, Slavin, & Sánchez, 2011, p.103). Nationally, ELLs constitute nine percent of all public school students and are enrolled in three out of every four public schools (U.S. DOE, & U.S. DOJ, 2015, p.1). The growing linguistic diversity within schools in the United States has produced a sense of urgency toward helping teachers support the academic success of language minority students (Molle, 2013).

As the population of ELLs has risen it has become clear that teachers are not well prepared to meet the needs of this demographic reality (García, Arias, Harris, & Serna, 2010, p.135). Despite the widespread call for professional development related to building teachers' aptitude to best meet and understand the needs of ELLs, these resources typically remain underrepresented (August, & Shanahan, 2010; Ballantyne, Sanderman, & Levy, 2007; Janzen, 2008; U.S. Department of Education, NCES, 2001; Zehler, et al., 2003b).

There is an ongoing push in educational literature for all teachers and policymakers to familiarize themselves with the unique demands of educating ELLs (Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997).

> Given the achievement gap that exists between ELLs and their native-speaking counterparts in STEM subjects, as well as the growing numbers of ELLs in US schools, this becomes a critical issue, as academic success for these students depends on the effectiveness of instruction they receive not only in English as a Second Language classes (ESL), but in mainstream classrooms as well (DelliCarpini & Alonso, 2014, p.155).

Content-based language instruction has typically been taught by language specialist, including

ESL and ESOL (English for Speakers of Other Languages) teachers, however, due to the

inadequate content knowledge of ESL and ESOL teachers, the success of this approach has been

limited (Lee, Quinn, & Valdés, 2013, p.228). For ELL students to have adequate opportunity to

academic achievement, general education teachers who possess the content knowledge and

pedagogy to teach to the grade level standards will also need to develop knowledge and skills

specific to ELLs (Samson, & Collins, 2012, p.2). "To help English learners catch up when they

fall short in core knowledge, all disciplines must practice vocabulary knowledge, reading, and

writing instruction" (Calderón, Slavin, & Sánchez, 2011, p.111).

Research on the current educational environment ELLs often face clearly illustrates the

shortcomings of the educational system in meeting the needs of this group of learners outside of

the core content classes.

> ELLs are often in classrooms and schools filled with nothing but ELLs, learning English
> from, and practicing it with, one another. They are provided instruction on English
> grammatical structures and vocabulary divorced from content that might make the
> linguistic materials meaningful or reveal how they might be deployed communicatively.
> They are taught to read with instruction focused on building decoding skills, and scant
> attention is given to reading for understanding or for learning (Fillmore, 2014, p.625).

Criticisms of educational environments that isolate ELLs from language-rich interaction with

their peers who are fluent in English provide further support for the necessity of preparing

general education teachers to accommodate the needs of this population within the context of the

traditional classroom.

Despite the increased demand for general education teachers to focus on the needs of

ELLs, teachers often lack the knowledge and institutional support necessary to address the

complex educational needs of ELLs (Lee, 2005, p.492). Ballantyne, Sanderman, and Levy

(2007) commented on this issue, stating: "The recent increase in ELLs in U.S. classrooms has been rapid, and teacher education and professional development has not yet caught up with the demographic shift" (p.10). Additional research displays that many teachers may have fundamental misunderstandings or confusion about how long it takes for a student to acquire a new language, how speaking a language other than English at home impacts a student's learning of English, and the correlation between speaking ability in English and English comprehension (Ballantyne, Sanderman, & Levy, 2007; Karabenick, & Clemens Noda, 2004; Reeves, 2006). These issues are fundamental to preparing teachers to meet the needs of ELL students, and the absence of this knowledge is also reflected in teachers' perceptions of their own abilities. Research on teachers' perceptions shows that they are not confident in their ability to effectively teach ELLs (Reeves, 2006; U.S. Department of Education, NCES, 2001), and that they would like to have more instruction on this topic (Alexander, Heaviside, & Farris, 1999).

The National Education Association (2011) advocates that general education teachers be provided practical, research-based information, resources, and strategies to teach, evaluate, and nurture ELL students if they are to succeed (p.3). However, access to these resources has been noted as missing. Samson and Collins (2012) reported, "in our review of the research, we identified oral language development, academic language, and cultural diversity as critical bodies of knowledge and skill areas for all teachers of ELLs that were noticeably absent in the areas of policy and practice" (p.20). As the needs of ELLs gain national attention, educational researchers continue to advocate that expectations for improved student outcomes should be rooted in support for teachers (Calderón, Slavin, & Sánchez, 2011, p.119).

In concurrence with a push for reforms in teacher education and training to meet the needs of ELLs there is also a call for research on effective strategies for educating this group of

students. August and Shanahan (2010) stated "there still are not enough studies exploring what works with English learners" (p.344). In discipline specific investigations there has been a noted absence of research on effective ways to prepare Mathematics and Science educators to work with English Language Learners (ELLs) in mainstream Mathematics and Science classrooms (DelliCarpini & Alonso, 2014; Lee, 2005). More broadly, Samson and Collins (2012) wrote, "Currently, at the various stages of teacher preparation, certification, and evaluation, there is insufficient information on what teachers should know about teaching ELLs" (p.8). This lack of research into effective strategies for educating ELLs and preparing teachers to implement such strategies highlights a need for further investigations into these issues from multiple fields of research.

A growing body of literature on STEM educational initiatives shows overlapping interest with work on ELLs' educational needs. Core tenants of STEM educational practices, such as project-based learning, have been supported in literature on meeting the needs of ELLs in STEM focused courses. Project-Based Learning (PBL) opportunities provide contextualized experiences for students to build meaningful understanding of STEM curricular concepts through critical and analytical thinking, collaboration with peers, self-directed learning, and the solving of real-world problems (Capraro, Capraro, & Morgan, 2013, p.2). Collaborative groups are a core feature of modern STEM education principles (Breiner, Harkness, Johnson, & Koehler, 2012) and the use of cooperative learning to support the needs of ELLs is widely supported by researchers (August, & Shanahan, 2010; Calderón, Slavin, & Sánchez, 2011; Fillmore, 2014; Krashen, 1981; Pereira & de Oliveira, 2015). Furthermore, tactile activities that utilize hands-on learning experiences and manipulatives, are also characteristic of STEM education PBL activities and have been reported as an effective tool for educating English Language Learners (Honigsfeld, & Dunn,

2009, p.221). These overlapping ideologies in conjunction with the national interest in both STEM education and ELLs supports a need for investigation into the capacity of STEM educators to meet the needs of ELL populations.

In the United States, the fastest-growing student group is children of immigrants, half of whom are categorized as ELLs (Calderón, Slavin, & Sánchez, 2011, p.103). The "context of reception" (Portes, & Rumbaut, 2001; Schwartz, et al., 2014) that these students face when entering into the K-12 education system is heavily impacted by the level of preparedness of their educators. An educational system that fails to meet the needs of diverse learners contributes to a negative perception of opportunities within the educational environment and in the labor market beyond school (Portes, & Böröcz, 1989; Portes, & Rumbaut, 2014). Due to their specific language needs, ELLs are at greater jeopardy of struggling academically (Honigsfeld, & Dunn, 2009). However, the state of STEM educators' preparedness to meet the needs of these learners is not yet known. As the nation turns its focus toward preparing the next generation to fill positions in STEM careers there is a growing need for research that investigates and compares teacher preparedness for working with ELLs between the STEM disciplines.

Research Questions

This investigation will be guided by a central research question regarding the credentialing of STEM educators in relation to ELLs in an effort to construct a national profile of STEM educators.

1) Between the STEM education disciplines, within and across regions, what are the ELL specific credentials teachers hold?

a) What are STEM teachers' service loads of ELLs?

b) What percentage of STEM teachers hold Language related credentials?

c) What percentage of STEM teachers hold Culture related credentials?

d) What amount of ELL focused professional development do STEM teachers participate in yearly?

This question will be explored through variable isolation of the most recent Schools and Staffing Survey (SASS) Teacher Questionnaire data.

Instrumentation

This study employed data from the most recently available Schools and Staffing Survey (SASS). Of the five questionnaires that make up the SASS: a School District Questionnaire, Principal Questionnaire, School Questionnaire, Teacher Questionnaire, and School Library and a Media Center Questionnaire, the Schools and Staffing Survey Teacher Questionnaire (SASS TQ) was specifically utilized. This study analyzed data from the restricted-use data files of the 2011-2012 SASS TQ which contains variables not available in the public-use data set. Tourkin, Thomas, Swaim, Cox, Parmer, Jackson, Cole, and Zhang, (2010) concisely describe the SASS as:

> The Schools and Staffing Survey (SASS) is conducted by the National Center for Education Statistics (NCES) on behalf of the U.S. Department of Education in order to collect extensive data on American public and private elementary and secondary schools. SASS provides data on the characteristics and qualifications of teachers and principals, teacher hiring practices, professional development, class size, and other conditions in schools across the nation. The overall objective of SASS is to collect the information necessary for a comprehensive picture of elementary and secondary education in the United States. The SASS was designed to produce national, regional, and state estimates for public elementary and secondary schools and related components and is an excellent resource for analysis and reporting on elementary and secondary educational issues (p.1).

This exploratory study examines STEM teachers' credentialing related to English Language Learners as well as the differences in the numbers of ELLs served by STEM teachers across regions and nationally during the 2011-2012 school year.

Variables Analyzed

Regional information is included within the SASS TQ dataset as a derived variable from the provided state-level information from participants. The regional categories are: Northeast (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin), South (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia), and West (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) (Tourkin, et al., 2010, p.1020). Service loads of ELLs will be measured by responses to Question 15 of the SASS TQ:

> Of all the students you teach at this school, how many are of limited-English Proficiency or are English-language learners (ELLs)? (Students of limited-English proficiency [LEP] or English-language learners [ELLs] are those whose native or dominant language is other than English and who have sufficient difficulty speaking, reading, writing, or understanding the English language as to deny them the opportunity to learn successfully in an English-speaking-only classroom.) (NCES, 2014, p.10)

Teachers' participation in professional development related to teaching ELLs will be determined by responses to question 49a, "In the past 12 months, have you participated in any professional development on how to teach limited-English proficient students or English-language learners (ELLs)?" (National Center for Educational Statistics, 2014, p.31). Hours spent on professional development for educating ELLs will be determined by responses to question

49b, "In the past 12 months, how many hours did you spend on these activities?" (National

Center for Educational Statistics, 2014, p.31). The level of participation in professional

development was measured by Question 49b which is structured on a four-level ordinal scale

from "8 hours or less", "9-16 hours", "17-23 hours", to "33 hours or more" (NCES, 2014, p.31).

Teachers' credentials will be measured by degrees, graduate certificates, or state-level

certifications in response to questions 25a, 25d, 25e, 25f, 27a, 27e, 28, 37a, 37b, 37d, 38a, 38b,

38c, 38d,and 38e (NCES, 2014). This set of questions covers bachelor's degrees, second majors,

master's degrees, doctorate or professional degrees, and primary as well as secondary state

teaching certificates. From responses to this set of questions, credentials will be categorized as

Cultural credentials if they are marked as response codes 222 (Area or ethnic studies, excluding

Native American Studies), 224 (Cultural studies), 231 (Native American Studies), 221

(Anthropology), or 229 (International Studies); and they will be categorized as Linguistic

credentials based on response codes of 160 (ESL or bilingual education: General), 161 (ESL or

bilingual education: Spanish), 162 (ESL or bilingual education: Other), or 156 (Linguistics)

(NCES, 2014, p.15). The category codes that comprise the grouped variables of Cultural and

Linguistic credentials were chosen from the complete list of possible response codes included in

the SASS TQ survey. These codes best reflect the credentialing that is relevant to the categories

of Cultural and Linguistics. As composite variables these categories serve as indicators of

preparation in the fields of Cultural and Linguistic. As such, from the total list of possible

response codes for participants' degrees, certificates, or state certifications, the codes

representing Area or ethnic studies, Cultural studies, Native American Studies, Anthropology,

and International Studies were chosen as the best representatives of credentialing related to

Culture. Similarly, the response codes corresponding to ESL or bilingual education: General,

ESL or bilingual education: Spanish, ESL or bilingual education: Other, and Linguistics were chosen to comprise the group denoted as Linguistic credentials. In addition to participants' degrees and graduate certificates, state-level certifications were included as indicators of credentialing. Response codes to questions in the SASS TQ regarding state-level certification areas indicate that a participant holds credentials that certify them to teach in the subject matter indicated by their response codes. The response codes used for degree and graduate certificate content areas carry over for state certifications and thus the same rationale was used to choose the specific codes that best fit the categories of Cultural and Linguistic credentials in regards to any degrees or graduate certificates a participant held.

Participant Description

The target population for this investigation was K-12 STEM educators, who for the purposes of this analysis are separated into the categories of Science, Technology, and Mathematics. Placement into these categories will be determined by question 16 of the SASS TQ, "This school year, what is your MAIN teaching assignment field at THIS school?" (National Center for Educational Statistics, 2014b, p.10). Teachers with response codes of 210(Science, general), 211(Biology or life sciences), 212(Chemistry), 213(Earth Science), 215(Integrated Science), 216(Physical Sciences), or 217(Physics) will be categorized as Science teachers for this study. Teachers will be categorized as Technology educators if they responded with the category code of 246 (Construction trades, engineering, or science technologies (including CADD and drafting), 247 (Manufacturing and precision production (electronics, metalwork, textiles, etc.), 250 (Communications and related technologies (including design graphics, or printing; not including computer science), or 255 (Industrial arts or technology education). Lastly, teachers will be categorized as Mathematics educators if they responded with the category code of 191

(Algebra I), 192 (Algebra II), 193 (Algebra III), 194 (Basic and general Mathematics), 195

(Business and applied math), 196 (Calculus and pre-calculus), 198 (Geometry), 199 (Pre-

algebra), 200 (Statistics and probability), or 201 (Trigonometry). The category codes of 197

(Computer science) and 214 (Engineering) were not included in the analysis since they did not

clearly fit into any one particular category despite being listed under Mathematics and Natural

Sciences respectively within the SASS TQ. Demographic information regarding number of

teachers, average age, and average years of experience teaching for the STEM disciplines is

tabulated in Table 2-1.

Table 2-1. STEM Teachers' Demographics Nationally (2011-2012)

	Number of Teachers	Average Age	Average Years of Experience
Science	226700	41.63	12.75
Mathematics	281990	41.00	13.01
Technology	50610	46.72	15.48

Methods

This study conducted a secondary analysis of the 2011-2012 SASS TQ restricted-use

license dataset. This data was used to create a national profile of the ELL related credentials

STEM teachers hold. The National Center for Educational Statistics (NCES) and Institute for

Educational Sciences (IES) require that all weighted n's were rounded to the nearest 10 to assure

participant anonymity. As such, the data included in tables may not add to the total N reported

due to rounding adjustments. Per National Center for Educational Statistics' recommendations

when analyzing weighted data from the SASS TQ dataset any figures that had a weighted

response value of less than 50 are noted as not being stable. Weighted data that was found to be unstable is replaced with an asterisk in the tables.

Results

Information gathered from the 2011-2012 SASS TQ dataset regarding STEM teachers' credentialing related to ELLs, professional development participation regarding ELLs, and rates of interactions with ELLs are summarized in tables for both national and regional data. Descriptive analysis illustrates the differences between the STEM disciplines as well as between regions within the United States. Tables 2-2 and 2-3 summarize the national data on STEM teachers credentialing related to and involvement with ELLS. Within the STEM disciplines nationally the majority of teachers reported having at least one ELL student in their service load of all the students they taught that year. Nationally Mathematics teachers had the highest percentage of teachers with ELL students in the STEM disciplines, 59.1%, yet Technology teachers had the highest mean number of ELL students in their class, 7.60. Despite over half of all teachers in the STEM disciplines reporting that they had ELL students, less than a quarter of teachers in any of the STEM disciplines participated in ELL specific professional development activities in the last year. Mathematics teachers had the highest rate of participation in ELL specific professional development activities nationally with 24.82% having taken part in some amount of professional development. For Science teachers 23.38% had taken part in some amount of ELL specific professional development within the last year and 18.97% of Technology teachers had done so. Of all the STEM teachers who had participated in ELL specific professional development activities, the majority of participants indicated that they had spent 8 hours or less on these activities. Across all of the STEM disciplines nationally, the number of participants who indicated that they possessed a degree, graduate certificate, or state

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certification in an area that was categorized as either Cultural or Linguistic was low. Cultural

degrees and Linguistic state-level certifications were the most common credentials that

participants possessed nationally, however, rates were small.

Table 2-2. STEM Teachers' ELL Related Credentials Nationally (2011-2012)

	Percentage of Teachers with ELLs	Overall Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
Science	58.4%	7.10	420/226700 0.19%	2960/226700 1.31%	6810/226700 3.00%	990/226700 0.44%
Mathematics	59.1%	5.98	70/281990 0.02%	1500/281990 0.53%	5000/281990 1.77%	2010/281990 0.71%
Technology	50.8%	7.60	0/50610 0%	610/50610 1.21%	520/50610 1.03%	80/50610 0.16%

Table 2-3. STEM Teachers' ELL Related Professional Development Nationally (2011-2012)

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
Science	58.4%	23.38%	38210/226700 16.85%	8760/226700 3.86%	3090/226700 1.36%	2950/226700 1.30%
Mathematics	59.1%	24.82%	51580/281990 18.29%	11080/281990 3.93%	3640/281990 1.29%	3680/281990 1.31%
Technology	50.8%	18.97%	6560/50610 12.96%	1410/50610 2.79%	1190/50610 2.35%	440/50610 0.87%

Regional analysis of STEM teachers' credentialing related to ELLs, ELL specific

professional development participation, and rates of interactions with ELLs demonstrates the

variances between the national and regional conditions. Descriptive analysis of the Northeast

region, which includes the states of Connecticut, Maine, Massachusetts, New Hampshire, New

Jersey, New York, Pennsylvania, Rhode Island, and Vermont, is summarized in tables 2-4 and 2-

5. For teachers within the STEM disciplines in the Northeast region, the percentage of teachers

who have ELLs in their overall service load of students and the average number of ELLs in the

teachers' service loads are lower than the corresponding national rates and averages. The

percentage of STEM teachers who participated in ELL specific professional development

activities in the last year is also lower than the nation average for all of the STEM disciplines.

Notably, Technology educators in the Northeast region were closer to the national rates for

Technology teachers in their participation in ELL specific professional development activities

than Science or Mathematics teachers in the Northeast were to their associated national rates.

Percentages of STEM teachers in the Northeast region who have a Linguistic or Cultural degree

or certification are similar to the national rates. A notable difference is that 3.65% of Science

teachers in the Northeast region reported possessing a degree in the Cultural category. That

percentage is more than twice the national rate of 1.31%.

Table 2-4. Northeastern STEM Teachers' ELL Related Credentials (2011-2012)

	Percentage of Teachers with ELLs	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
Science	46.6%	4.61	0/45480 0%	1660/45480 3.65%	370/45480 0.81%	160/45480 0.35%
Mathematics	52.5%	4.24	0/56230 0%	140/56230 0.25%	740/56230 1.32%	600/56230 1.07%
Technology	44.3%	5.32	0/13950 0%	90/13950 0.65%	0/13950 0.00%	*

Table 2-5. Northeastern STEM Teachers' ELL Related Professional Development (2011-2012)

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
Science	46.6%	13.69%	4580/45480 10.07%	570/45480 1.25%	550/45480 1.21%	520/45480 1.14%
Mathematics	52.5%	16.78%	6400/56230 11.38%	1600/56230 2.85%	1220/56230 2.17%	220/56230 0.39%
Technology	44.3%	14.05%	1560/13950 11.18%	*	230/13950 1.65%	110/13950 0.79%

The Midwest region, which includes the states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin, had the lowest rates of STEM teachers with ELLs and the lowest average number of ELLs in their service loads among the regions. Tables 2-6 and 2-7 display the descriptive analysis of the Midwest region. Relatedly, STEM teachers in the Midwest had the lowest rates of participation in ELL specific professional development activities among the regions. For both Mathematics and Technology teachers in the Midwest, the rates of participation in ELL specific professional development activities were less than half of their respective national rates. Credentials were also lower than the corresponding national averages for all categories except Science teachers with Cultural Certifications.

Table 2-6. Midwestern STEM Teachers' ELL Related Credentials (2011-2012)

	Percentage of Teachers with ELLs	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
Science	43.1%	2.80	200/48810 0.41%	110/48810 0.23%	750/48810 1.54%	180/48810 0.37%
Mathematics	41.1%	3.13	*	60/57550 0.10%	780/57550 1.36%	110/57550 0.19%
Technology	43.1%	3.35	0/11580 0%	50/11580 0.43%	0/11580 0%	0/11580 0%

Table 2-7. Midwestern STEM Teachers' ELL Related Professional Development (2011-2012)

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
Science	43.1%	12.26%	4480/48810 9.18%	1010/48810 2.07%	190/48810 0.39%	300/48810 0.61%
Mathematics	41.1%	11.55%	5220/57550 9.07%	1010/57550 1.76%	150/57550 0.26%	260/57550 0.45%
Technology	43.1%	9.08%	900/11580 7.77%	90/11580 0.78%	60/11580 0.52%	0/11580 0%

Tables 2-8 and 2-9 display the descriptive analysis of the Southern region which includes the states of Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. While the national rates of teachers who had ELLs in their service loads for Science and Mathematics teachers in the Southern region were slightly higher than their corresponding national averages, the rate for Technology educators fell slightly below the national rate. The average number of ELLs in Southern STEM teachers' service loads are

slightly lower than their national averages. The percentage of STEM teachers in the South who

reported having a state-level Linguistic certification were higher than the national rates for all of

the disciplines. Similarly, the percentage of STEM teachers in the South who participated in ELL

specific professional development activities in the last year was higher than the national rates for

each discipline.

Table 2-8. Southern STEM Teachers' ELL Related Credentials (2011-2012)

	Percentage of Teachers with ELLs	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
Science	63.5%	7.06	80/91810 0.09%	550/91810 0.60%	4030/91810 4.39%	290/91810 0.32%
Mathematics	61.8%	4.55	0/117046 0%	890/117050 0.76%	2550/117050 2.18%	90/117050 0.08%
Technology	50.6%	7.01	0/16930 0%	*	370/16930 2.19%	0/16930 0%

Table 2-9. Southern STEM Teachers' ELL Related Professional Development (2011-2012)

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
Science	63.5%	29.34%	20370/91810 22.19%	4500/91810 4.90%	1390/91810 1.51%	680/91810 0.74%
Mathematics	61.8%	29.59%	26630/117050 22.75%	5550/117050 4.74%	670/117050 0.57%	1790/117050 1.53%
Technology	50.6%	22.00%	2580/16930 15.24%	690/16930 4.08%	450/16930 2.66%	0/16930 0%

Regional analysis of STEM teachers in the West, which includes the states of Alaska,

Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah,

Washington, and Wyoming, is displayed in tables 2-10 and 2-11. STEM teachers in the Western region had the highest rates of teachers with ELLs in their service loads as well as the highest average number of ELLs in teachers' service loads of any region. For Science teachers, 78.5% reported having ELLs, with 80.3% of Mathematics, and 73.3% of Technology teachers also reporting ELLs in their service loads. Despite having both higher rates and average numbers of ELLs in service loads than STEM teachers in the Southern region, STEM teachers in the West had slightly lower rates of state-level Linguistic certifications than the corresponding rates for Southern STEM teachers. However, the rates of state-level Linguistic certifications for STEM teachers in the Western region were still slightly higher than the respective national averages. A notable difference in credentialing in the Western region is the percentage of Technology teachers, 5.52%, who reported having a Cultural degree. This rate is well above the national rate of 1.21% for Technology teachers. The percentage of STEM teachers in the Western region who participated in ELL specific professional development activities in the last year was higher than the national rates and the other regional rates for each discipline.

Table 2-10. Western STEM Teachers' ELL Related Credentials (2011-2012)

	Percentage of Teachers with ELLs	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
Science	78.5%	15.15	140/40600 0.34%	640/40600 1.58%	1670/40600 4.11%	350/40600 0.86%
Mathematics	80.3%	14.35	*	410/51170 0.80%	930/51170 1.82%	1220/51170 2.38%
Technology	73.3%	18.78	0/8150 0%	450/8150 5.52%	150/8150 1.84%	70/8150 0.86%

Table 2-11. Western STEM Teachers' ELL Related Professional Development (2011-2012)

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
Science	78.5%	34.13%	8780/40600 21.63%	2680/40600 6.60%	950/40600 2.34%	1460/40600 3.60%
Mathematics	80.3%	37.63%	13330/51170 26.05%	2910/51170 5.69%	1600/51170 3.13%	1410/51170 2.76%
Technology	73.3%	35.15%	1520/8150 18.65%	610/8150 7.48%	400/8150 4.91%	330/8150 4.05%

Discussion and Conclusion

The growing ELL population across the nation has led researchers to emphasize the need for general education teachers to adapt instructional methodologies to better suit the needs of ELLs in their classrooms (Lee, 2005; Janzen, 2008). This initiative has also highlighted the need for large-scale investigations into the current state of educators' preparedness to meet the needs of ELLs in the K-12 system. Concurrent with the national attention put on STEM education courses, this study examined potential indicators of STEM teachers' preparedness to educate ELLs. Literature states that STEM teachers are not well prepared to meet the needs of ELLS (DelliCarpini & Alonso, 2014; García, Arias, Harris, & Serna, 2010). However, further investigation of the relationship between STEM teachers and ELLs has been called for (DelliCarpini & Alonso, 2014; Lee, 2005). Data gathered from the 2011-2012 SASS TQ in this study shows the varying states of STEM teachers' credentialing and professional development participation related to ELLs both nationally and regionally.

Findings from this study indicate differences between the frequency and intensity of ELL participation in STEM courses, with a lower percentage of teachers in some disciplines having any ELL students and yet having on average a larger number of ELL students in their service loads. Although nationally in all of the STEM disciplines more than half of the participants indicated having ELLs in their courses, Technology education had the lowest percentage with 50.8% of teachers indicating that they had ELLs, but had the highest average number of ELLs in there service loads with an average of 7.60 ELLs. Regional analysis of STEM teachers' preparation for educating ELLs showed the vast differences across the nation. The Western region had the highest percentage of teachers with ELLs in their service loads for every discipline while the Midwest had the lowest. Relatedly, STEM teachers in the Western region also reported the highest rates of participation in ELL specific professional development activities. Findings from regional analysis suggest a link between the percentage of STEM teachers in a region with ELLs in their service load and participation in ELL specific professional development opportunities. These findings can lead to insights on the situation nationally and regionally as well as serving to direct future efforts to improve the educational experiences of ELLs in STEM disciplines.

The findings of this study show that nationally over half of all STEM teachers have ELLs in their classes yet less than a quarter of STEM teachers participated in ELL specific professional development activities. These comparative rates of ELLs in classes to the professional development participation could encourage programs to provide more professional development opportunities. While it is reported that ELLs constitute nine percent of all public school students (U.S. DOE, & U.S. DOJ, 2015, p.1), this information may be less impactful to some than the fact that nationally in STEM fields the majority of teachers indicated having ELLs in their service

loads of students. Even in regions where ELLs were less common, across all of the STEM disciplines more than 40% of teachers reported having ELLs in their classes.

These findings also show that both nationally and in all regions for all of the STEM disciplines the majority of participants who indicated that they had taken part in ELL specific professional development in the last year indicated having eight or less hours of these activities. While professional development opportunities are supported as a means to build skills for working effectively with ELLs (Ballantyne, Sanderman, & Levy, 2007; Calderón, Slavin, & Sánchez, 2011), some researchers advocate for long-term programs (García, Arias, Harris, & Serna, 2010). As teachers adapt instructional methods to better suit the needs of their ELLs there will continue to be a need for studies that investigate effective instructional practices of STEM teachers working with ELLs as well as impactful professional development models for empowering teachers with these research-based skills and understandings.

The findings of this study could be further advanced through studies of specific issues STEM teachers face when working with ELLs and how targeted professional development models could serve to build appropriate methods for adapting STEM curriculum to best suit the needs of this population of learners. Furthermore, longitudinal studies could lend insight into how STEM educators are preparing to meet the needs of this growing population of ELLs nationally and regionally. Targeted efforts should also be made in encouraging collaboration between experts in STEM disciplines and language specialist to make efficient use of the practices and methodologies that are best suited to engage ELLs in STEM disciplines in ways that support their unique learning needs.

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Chapter 3. Manuscript Two

Developments in STEM Educators' Preparedness for English Language Learners in the United States

Keith Besterman

Abstract

Background

The growing population of students classified as English Language Learners (ELLs) in the K-12 education system in the United States has led to increased emphasis on the need for teachers outside of specialized linguistic courses to adapt instruction to better meet the needs of these students. Due to the national emphasis on STEM education to prepare students to work in an increasingly STEM-focused job market, STEM teachers' preparedness to meet the needs of a growing ELL population requires investigation. This exploratory study investigates potential indicators of STEM teachers' preparedness to work with ELLs in comparison with the rates of ELLs in STEM courses.

Results

Data for this study was collected and analyzed using the national restricted access datasets of the 2007-2008 and 2011-2012 School and Staffing Survey (SASS) Teacher Questionnaire (TQ). STEM teachers' participation in ELL focused professional development activities, credentialing related to ELLs, and ELL populations in STEM teachers' courses were analyzed over the timespan between the two datasets. Results from this study compared changes in these measures over time and between the STEM disciplines. Regional analysis of STEM teacher populations and ELL populations in STEM classes was also conducted to examine how these factors differed across the United States.

Conclusions

Findings from this study indicate that nationally in all of the STEM disciplines the percentage of STEM teachers who have ELLs in their service loads as well as the average number of ELLs teachers have in their service loads are increasing. Simultaneously, the total number of teachers in each STEM discipline who participated in ELL focused professional development activities increased only slightly over the four year span. For some of the STEM disciplines these growths were so small that the overall percentage of teachers in the discipline that took part in these activities actually decreased.

Keywords

STEM education, School and Staffing Survey Teacher Questionnaire, English Language Learners

Background

Across the United States English Language Learners (ELLs) constitute nine percent of all public school students and are enrolled in three out of every four public schools (U.S. DOE, & U.S.DOJ, 2015, p.1). Furthermore, children of immigrants, half of whom do not speak English fluently and are thus labeled English learners, are the fastest-growing student population in U.S. schools (Calderón, Slavin, & Sánchez, 2011, p.103). Growth projections of the ELL population speculate that by the 2030s the number of Language Minority (LM) students will constitute 40 percent of the school-age population (Thomas & Collier, 2001, p.1). The rising numbers of students classified as ELLs in the K-12 education system has amplified national attention on helping teachers support the academic success of language minority students (Molle, 2013; NCES, 2016). Despite the increased attention on this group of learners, teachers are not yet well prepared to meet the needs of this emergent learner population (García, Arias, Harris, & Serna, 2010, p.135). This population is of particular concern since students who grew up in English language isolated communities, or do not speak English because they are from a country whose primary language is not English, are at greater jeopardy of struggling academically (Honigsfeld, & Dunn, 2009). Research not only indicates that the ELL population is growing, but also that across the United States areas that have not traditionally served large ELL populations are now experiencing sizable increases in their ELL student body (Cheung, & Slavin, 2012; National Clearinghouse on English Language Acquisition, 2010; Pereira, & de Oliveira, 2015).

The scale of the ELL population within a state varies hugely across the United States. Data from the National Center for Educational Statistics (2015) found that California had the highest percentage of ELL students with 22.7 percent of the public school population being classified as ELL, and West Virginia had the lowest percentage with 0.7 percent of the public

school population being classified as ELL (p.1). This uneven distribution of the ELLs across the

U.S. makes addressing the needs of this population of learners from a federal level complex.

Calderón Slavin and Sánchez (2011) stated,

> Although the federal government requires districts to provide services to English learners, it offers states no policies to follow in identifying, assessing, placing, or instructing them. States, therefore, vary widely in the policies and practices by which they identify and assess English learners for placing within and exiting from instructional programs (p.104).

As such, issues related to meeting the needs of ELLs are often contextualized at a state level. At

the state level it is common for a simplified version of the federal definition or a specific

definition that is tailored to the needs of the community to be used (Hopstock, Bucaro,

Fleischman, Zehler, Eu, 1993; Zehler, et al., 2003).

Content-based language instruction is often presented to ELLs by language specialist,

including ESL (English as a Second Language) and ESOL (English for Speakers of Other

Languages) teachers; however, the success of this approach is limited by the extent of ESL and

ESOL teachers' content knowledge in other academic disciplines (Lee, Quinn, & Valdés, 2013,

p.228). As the population of ELLs grows, general education teachers will have to augment their

content knowledge and pedagogy with knowledge and skills specific to ELLs to ensure that all of

their students are able to reach the grade level standards (Samson, & Collins, 2012, p.2).

Calderón Slavin and Sánchez (2011) suggest "To help English learners catch up when they fall

short in core knowledge, all disciplines must practice vocabulary knowledge, reading, and

writing instruction" (p.111). The need for all teachers and policymakers to familiarize

themselves with the unique demands of educating ELLs is garnering growing attention in

educational literature (Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997). Unfortunately,

throughout the field of education, reforms to meet the needs of ELLs are trailing behind the

actual growth of ELLs in classrooms (August, Shanahan, & Escamilla, 2009; Ballantyne,

Sanderman, & Levy, 2007; Menken, & Antunez, 2001).

Even though general education teachers are increasingly being asked to adapt instruction

for ELLs, many educators lack the institutional support and specific expertise needed to address

the complex educational needs of ELLs (Lee, 2005, p.492). Educational literature supports the

notion that the quality of instruction a student recieves is heavily dependent on the abilities of

their educator and that expectations for student advancement should be rooted in support for

teacher improvement (Calderón, Slavin, & Sánchez, 2011; Cheung, & Slavin, 2012). Teacher

training, education, and certification present opportunities for improvement of teaching practices,

and in particular could be utilized to prepare educators to better serve their ELL students (Daniel,

2014; Darling-Hammond, 1996; Molle, 2013; Nadelson, Seifert, Moll, & Coats, 2012). In a

review of literature related to teaching academic English to ELLs, DiCerbo, Anstrom, Baker, and

Rivera (2014) noted "The literature reviewed suggests that high-quality professional

development can provide meaningful learning experiences for teachers on academic English

within subject area contexts" (p.472). Building up the capabilities of mainstream educators to

work more effectively with ELLs is an essential component of a successful education system.

Since broadly introduced in 2001 by the National Science Foundation (NSF), the term

STEM education has gained mainstream popularity (Marrero, Gunning, & Germain-Williams,

2014; Sanders, 2009). STEM education reforms offer potential benefits for all students and

overlap with proposed best-practices of ELL focused reforms. However, the achievement gap

between ELLs and their native-speaking peers in STEM subjects further highlights the missed

educational opportunities ELLs face when mainstream teachers are not prepared to meet the

unique needs of ELLs (DelliCarpini & Alonso, 2014, p.155). Educational methodologies that

have an emphasis on STEM often utilize Project-Based Learning (PBL) opportunities to contextualize course content and build meaningful understandings through critical and analytical thinking, collaboration with peers, self-directed learning, and real-world problem solving (Capraro, Capraro, & Morgan, 2013, p.2). The use of tactile activities that employ hands-on learning experiences and manipulatives have also been reported as a core feature of STEM education PBL activities as well as an effective approach to learning for ELLs (Honigsfeld, & Dunn, 2009, p.221). Furthermore, the utilization of collaborative groups is a notable feature of STEM education (Breiner, Harkness, Johnson, & Koehler, 2012) as well as a widely supported instructional methodology for ELLs (August, & Shanahan, 2010; Calderón, Slavin, & Sánchez, 2011; Fillmore, 2014; Krashen, 1981; Pereira & de Oliveira, 2015). STEM disciplines are promoted as key components of a 21st century education to prepare students for a knowledge based workforce (Bybee, 2010; Marrero, Gunning, Germain-Williams, 2014). As such, it is critically important that STEM educators are prepared to meet the learning needs of ELLs within these disciplines (Lee, 2005; Janzen, 2008).

The rapid growth of the ELL population continues to garner national attention to this group of learners (Calderón, Slavin, & Sánchez, 2011). Additionally, the quality of the educational environment ELLs find when entering the K-12 system in the United States is directly impacted by teachers' level of preparedness to meet the needs of this population (Calderón, Slavin, & Sánchez, 2011; Cheung, & Slavin, 2012). Barriers to academic success for ELLs would contribute to a negative "context of reception" (Portes, & Rumbaut, 2001; Schwartz, et al., 2014), particularly for ELL students who are children of immigrants. Currently, students categorized as ELLs are at risk of struggling academically (Honigsfeld, & Dunn, 2009), and the preparedness of their educators contributes to their potential for success (DelliCarpini &

Alonso, 2014). Failing to meet the needs of diverse learners in the K-12 system can have a lasting effect on their perceptions of opportunities within and beyond school (Portes, & Böröcz, 1989; Portes, & Rumbaut, 2014). There is a continued need for research on teacher credentialing related to meeting the needs of English Language Learners at a national-level to inform policy and practices (DelliCarpini & Alonso, 2014; Lee, 2005).

Research Questions

This exploratory investigation is guided by three core research questions related to changes in both the population of ELLs in STEM courses and the credentialing of STEM educators related to ELLs.

1) To what extent has the number of ELLs changed over time across the STEM disciplines nationally?

    a) Have STEM teachers' service-loads of ELLs changed over time?

2) To what extent have STEM educators' credentialing related to ELLs changed over time nationally?

    a) To what extent has the percentage of STEM teachers that hold Language related credentials changed over time?

    b) To what extent has the percentage of STEM teachers that hold Culture related credentials changed over time?

    c) To what extent has the amount of ELL focused professional development that STEM teachers participate in yearly changed over time?

3) To what extent have STEM teachers' service-loads of ELLs changed over time in the STEM disciplines within and across regions?

    a) Have STEM teachers' service-loads of ELLs changed over time regionally?

These questions will be explored through variable isolation of data from the most recent and the second-most recent Schools and Staffing Survey (SASS) Teacher Questionnaires (TQ).

Instrumentation

Data from the two most recently available Schools and Staffing Surveys (SASS) were employed in this study. The SASS consist of five complimentary questionnaires that make up the SASS: a School District Questionnaire, Principal Questionnaire, School Questionnaire, Teacher Questionnaire, and School Library and a Media Center Questionnaire. This investigation utilizes data solely from the Schools and Staffing Survey Teacher Questionnaire (SASS TQ). When describing the SASS, Tourkin, Thomas, Swaim, Cox, Parmer, Jackson, Cole, and Zhang, (2010) stated:

> The Schools and Staffing Survey (SASS) is conducted by the National Center for Education Statistics (NCES) on behalf of the U.S. Department of Education in order to collect extensive data on American public and private elementary and secondary schools. SASS provides data on the characteristics and qualifications of teachers and principals, teacher hiring practices, professional development, class size, and other conditions in schools across the nation. The overall objective of SASS is to collect the information necessary for a comprehensive picture of elementary and secondary education in the United States. The SASS was designed to produce national, regional, and state estimates for public elementary and secondary schools and related components and is an excellent resource for analysis and reporting on elementary and secondary educational issues (p.1).

Data was utilized to examine STEM teachers' certifications related to ELLs, changes in STEM teachers' service-load of ELLs, and regional analysis of related changes over time using data from the 2007-2008 and 2011-2012 school years.

Variables analyzed

Within the SASS TQ dataset, regional information is a derived variable created from the state-level information provided by participants. The regional categories are: Northeast

(Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin), South (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia), and West (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) (Tourkin, et al., 2010, p.1020). The service load of ELLs a teacher serves will be measured by responses to Question 15:

> Of all the students you teach at this school, how many are of limited-English Proficiency or are English-language learners (ELLs)? (Students of limited-English proficiency [LEP] or English-language learners [ELLs] are those whose native or dominant language is other than English and who have sufficient difficulty speaking, reading, writing, or understanding the English language as to deny them the opportunity to learn successfully in an English-speaking-only classroom.) (NCES, 2014, p.10)

Participation by teachers in ELL related professional development opportunities will be determined by responses to question 49a, "In the past 12 months, have you participated in any professional development on how to teach limited-English proficient students or English-language learners (ELLs)?" (National Center for Educational Statistics, 2014, p.31). Beyond participation, the number of hours spent on professional development relating to ELLs will be determined by responses to question 49b, "In the past 12 months, how many hours did you spend on these activities?" (National Center for Educational Statistics, 2014, p.31). Responses regarding the number of hours spent participating in ELL specific professional development in the last year was measured by Question 49b which is structured on a four-level ordinal scale from "8 hours or less", "9-16 hours", "17-23 hours", to "33 hours or more" (NCES, 2014, p.31).

For the purposes of this study teachers' degrees, graduate certificates, and state level certifications are represented in composite credential categories. Categories are separated by Linguistic and Cultural focus as well as separated through degrees or state-level certifications. Although the order of the questions in the SASS TQ change slightly between the 2007-2008 and 2011-2012 surveys the content of the questions remains the same and therefore comparisons between years can be made. Possession of specific degrees or state level certifications will be measured by responses to questions 25a, 25d, 25e, 25f, 27a, 27e, 28, 25g, 25h, 37a, 37b, 37d, 38a, 38b, 38c, 38d,and 38e of the 2011-2012 SASS TQ survey and the corresponding questions from the 2007-2008 dataset (NCES, 2014). These sections of questioning within the SASS TQ include the major field of study for bachelor's degrees, second majors, master's degrees, graduate certificates, doctorate or professional degrees, as well as the content area for primary as well as secondary state-level teaching certifications. Regarding participants bachelor's degrees, second majors, master's degrees, graduate certificates, and doctorate or professional degrees they are asked to provide a major field of study that best describes the focus of the degree using the provided table of response codes. Similarly, for participants' state-level certifications they are asked to indicate which response code best describes the content area that their certification allows them to teach in. Credentials specific to the scope of this investigation will be categorized as either Cultural Degrees, Cultural Certifications, Linguistic degrees, or Linguistic Certifications. Categorization into these groups is determined by response codes regarding the subject matter of the credential. The content codes for major field of study regarding degrees are also used for content area of state-level certification, thus the same response codes will be used by participants to indicate area of focus for degrees and state-level certifications. The categories of Cultural Degrees and Cultural Certifications represent response codes of 221 (Anthropology),

222 (Area or ethnic studies, excluding Native American Studies), 224 (Cultural studies), 231 (Native American Studies), or 229 (International Studies). The categories of Linguistic Degrees and Linguistic Certifications denote response codes of 160 (ESL or bilingual education: General), 161 (ESL or bilingual education: Spanish), 162 (ESL or bilingual education: Other), or 156 (Linguistics) (NCES, 2014, p.15). The response codes that are used to create the composite categories of Cultural credentials and Linguistic credentials are from a table of possible response codes included in the SASS TQ survey that allow for respondents to indicate the area of study a degree they possess is in or the area of study a particular state-level certification they possess allows them to teach in. The codes that comprise the categories of Cultural and Linguistic credentials were chosen from the complete list of possible response codes as those that best represented evidence of relevant knowledge to the concepts of either culture or linguistics. From all of the response codes included in the SASS TQ the codes representing Area or ethnic studies, Cultural studies, Native American Studies, Anthropology, and International Studies were chosen as the best representatives of credentialing related to Culture. To comprise the category of Linguistic credentials the response codes corresponding to ESL or bilingual education: General, ESL or bilingual education: Spanish, ESL or bilingual education: Other, and Linguistics were chosen as the most appropriate areas of focus.

Participant description

The target population utilized in this study is K-12 educators within STEM disciplines. Within the context of this study the classification of STEM disciplines is separated into the categories of Science, Technology, and Mathematics. Participants are placed into one of these groups based on subject matter codes given in response to question 16 of the SASS TQ, "This school year, what is your MAIN teaching assignment field at THIS school?" (National Center for

Educational Statistics, 2014b, p.10). Categorization as a Science teacher is determined by response codes of 210(Science, general), 211(Biology or life sciences), 212(Chemistry), 213(Earth Science), 215(Integrated science), 216(Physical sciences), or 217(Physics). Participants are categorized as Technology teachers if they responded with codes of 246 (Construction trades, engineering, or science technologies (including CADD and drafting), 247 (Manufacturing and precision production (electronics, metalwork, textiles, etc.), 250 (Communications and related technologies (including design graphics, or printing; not including computer science), or 255 (Industrial arts or technology education). Additionally, teachers will be categorized as Mathematics educators if they responded with the category code of 191 (Algebra I), 192 (Algebra II), 193 (Algebra III), 194 (Basic and general Mathematics), 195 (Business and applied math), 196 (Calculus and pre-calculus), 198 (Geometry), 199 (Pre-algebra), 200 (Statistics and probability), or 201 (Trigonometry). The category codes of 197 (Computer science) and 214 (Engineering) were intentionally not included in the aforementioned groupings since these codes are placed under the headings of Mathematics and Natural Sciences respectively within the SASS TQ but do not fit into the general understanding of what these headings represent.

Methods

This exploratory investigation utilized secondary analysis of the 2007-2008 and 2011-2012 SASS TQ restricted-use license datasets. A national profile of STEM teachers' credentials related to ELLs, regional differences in credentials, and changes over time in these categories was created and investigated using this data. In the utilization of the SASS dataset the National Center for Educational Statistics (NCES) and Institute for Educational Sciences (IES) require that all weighted n's are rounded to the nearest 10 to assure participant anonymity. Due to these

required rounding adjustments the data included in tables might not add to the total N reported. When analyzing weighted data from the SASS TQ dataset, the National Center for Educational Statistics' (NCES) recommends that any figures that had a weighted response value of less than 50 are noted as not being stable. Therefore, weighted data that was found to be unstable is replaced with an asterisk in the reported tables.

Results

National data gathered from the 2007-2008 and 2011-2012 SASS TQ dataset regarding STEM teachers' professional development participation regarding ELLs, credentialing related to ELLs, and rates of interactions with ELLs are summarized in tables reflecting the changes between the years of reporting. Regional data was also gathered and reported to identify changes in the percentages of STEM teachers who reported having ELLs in their overall service load of students as well as changes in the mean number of ELLs teachers had in the years reported. The focus of this study is the changes that have occurred in the data across the four year time span between the SASS TQ reports and as such data from the STEM disciplines are reported in separate tables. Although the graphical separation allows for clearer depictions of the growth and changes that have occurred in each specific discipline, comparisons between the findings for each discipline also add insight into developments in STEM education nationally.

The findings from the national data gathered regarding STEM teachers' rates of interactions with ELLs shows noticeable increases in both the percentage of teachers who reported having ELLs in their service loads as well as the average number of ELLs teachers had across all of the STEM disciplines. However, the rate of growth in the percentage of teachers who reported having ELLs in their service loads differed between the disciplines. These findings as well as changes in the populations of STEM teachers are shown in tables 3-1 and 3-2. While

Mathematics and Science both showed an increase in the percentage of teachers with ELLs in their service loads of more than 7% over the four year span, only 3.6% more Technology teachers reported having ELLs in their service loads in the later dataset. Conversely, Technology education had the highest growth over the four year span in the average number of ELLs teachers reported having. Interestingly, while Technology education had the lowest average number of ELLs in their service loads in the 2007-2008 dataset, in the 2011-2012 dataset they had risen to having the highest average amongst the STEM disciplines. Between both sets of data Mathematics educators had the highest percentage of teachers with ELLs in their service loads with 59.1% of Math teachers reporting having ELLs in their service loads by 2012.

Table 3-1. Changes in STEM Teachers' Demographics Nationally

	Number of Teachers	Average Age	Average Years of Experience
Science (2007-2008)	210529	42.24	13.13
Science (2011-2012)	226700	41.63	12.75
Mathematics (2007-2008)	280482	41.73	13.18
Mathematics (2011-2012)	281990	41.00	13.01
Technology (2007-2008)	54572	45.45	15.07
Technology (2011-2012)	50610	46.72	15.48

Table 3-2. STEM Teachers' ELL Population Changes

	Percentage of Teachers with ELLs 2007-08	Percentage of Teachers with ELLs 2011-12	Overall Mean Service Load of ELLs 2007-08	Overall Mean Service Load of ELLs 2011-12
Science	51.0%	58.4%	5.72	7.10
Mathematics	51.3%	59.1%	5.16	5.98
Technology	47.2%	50.8%	5.08	7.60

Findings from this study show increases in the percentage of Science teachers holding credentials in the categories of Cultural state-level Certifications, Cultural Degrees, and Linguistic Certifications. This information on Science teachers is displayed in Table 3-3. The category of Linguistic Certifications showed the most growth over the four year span. Surprisingly, table 3-4 displays that although the percentage of Science teachers who indicated that they had ELLs in their service loads increased over the four years, the percentage of teacher who responded that they had participated in ELL specific professional development activities in the past year decreased over the same time span. Furthermore, in both datasets over half of the Science teachers who did participate in ELL specific professional development had eight or fewer hours of such activities. It should be noted that due to the change in the total number of teachers between the datasets, both the percentage of teachers as well as the number of teachers who possess a credential should be examined in comparisons between years. This discrepancy is most notable in the percentage of teachers who participated in ELL specific professional development activities in the last year. For Science teachers, although the percentage of teachers who took part in ELL specific professional development decreased slightly the total number of teachers who took part increased slightly. This contrast displays that although the number of Science teachers who took part in these activities increased, the increase was not proportional to the increase in the overall number of Science teachers that took place in the four year time span.

Table 3-3. Changes in Science Teachers' ELL Related Credentials

	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
2007 - 2008	5.72	60/210530 0.03%	2710/210530 1.29%	1930/210530 0.92%	1220/210530 0.58%
2011 - 2012	7.10	420/226700 0.19%	2960/226700 1.31%	6810/226700 3.00%	990/226700 0.44%

Table 3-4. Changes in Science Teachers' ELL Related Professional Development

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
2007 – 2008	51.0%	52100/210530 24.75%	30730/210530 14.60%	8180/210530 3.89%	5950/210530 2.83%	7240/210530 3.44%
2011-2012	58.4%	53010/226700 23.38%	38210/226700 16.85%	8760/226700 3.86%	3090/226700 1.36%	2950/226700 1.30%

Data regarding Mathematics teachers' credentials, displayed in tables 3-5 and 3-6, showed an increase in the percentage of teachers who possessed a credential in the category of Cultural Degrees but a decrease in the prevalence of teachers with Linguistic Certifications and Linguistic Degrees. Similar to the findings regarding Science educators, a higher percentage of Mathematics educators indicated that they had ELLs in their service load in the later dataset but the percentage who had participated in ELL specific professional development activities in the last year largely stagnated over the four year span. Although the number of Mathematics teachers that took part in these professional development activities slightly increased the percentage of the total number of Mathematics teachers that did so decreased over the four year time span. Also common between Mathematics and Science teachers from both datasets was the fact that over half of the Mathematics teachers who participated in professional development activities specific

to ELLs in the last year had eight or fewer hours of such experiences. Of notable contrast between Mathematics and Science teachers is the spike in the number of Science teachers who had a state-level certifications in the category of Linguistic Certifications between the four year span of the datasets which was not reflected in the percentage of Mathematics teachers who had such credentials.

Table 3-5. Changes in Mathematics Teachers' ELL Related Credentials

	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
2007 - 2008	5.16	*	740/280480 0.26%	5280/280480 1.88%	2260/280480 0.81%
2011 - 2012	5.98	70/281990 0.02%	1500/281990 0.53%	5000/281990 1.77%	2010/281990 0.71%

Table 3-6. Changes in Mathematics Teachers' ELL Related Professional Development

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
2007 – 2008	51.3%	69690/280480 24.85%	42650/280480 15.21%	12580/280480 4.49%	5160/280480 1.84%	9300/280480 3.32%
2011-2012	59.1%	69980/281990 24.82%	51580/281990 18.29%	11080/281990 3.93%	3640/281990 1.29%	3680/281990 1.31%

The findings of this study regarding Technology educators are summarized in tables 3-7 and 3-8. These findings show that a higher percentage of Technology educators held credentials in the categories of Cultural Degrees and Linguistic Certifications in the 2011-2012 dataset than in 2007-2008. The percentage of Technology teachers who possessed a degree in the category of Linguistic Degrees decreased slightly. Notably, the number of Technology teachers who possessed a degree in the category of Cultural Degrees increased tenfold. Although the percentage of Science and Mathematics educators that possessed a degree in the category of Cultural Degrees also increased over the four year span this increase was much greater for

Technology educators. A notable finding is the fact that of the STEM disciplines Technology teachers experienced the smallest growth in the percentage of teachers who had ELLs in their service loads but were the only discipline to show growth in the percentage of teachers who had taken part in ELL specific professional development activities in the past year. It should be noted that the number of Technology teachers who took part in these activities only increased slightly, but in connection with the decrease in the overall number of Technology teachers the percentage that took part was noticeably higher in the later dataset. As was the case for Science and Mathematics teachers, of the Technology educators that took part in ELL specific professional development activities in the past year the majority of teachers had eight or fewer hours of these activities.

Table 3-7. Changes in Technology Teachers' ELL Related Credentials

	Mean Service Load of ELLs	Cultural Certification	Cultural Degree	Linguistic Certification	Linguistic Degree
2007 - 2008	5.08	0/54570 0%	60/54570 0.11%	330/54570 0.60%	110/54570 0.20%
2011 - 2012	7.60	0/50610 0%	610/50610 1.21%	520/50610 1.03%	80/50610 0.16%

Table 3-8. Changes in Technology Teachers' ELL Related Professional Development

	Percentage of Teachers with ELLs	ELL Related Professional Development Participation	8 or Less Hours	9-16 Hours	17-32 Hours	33 or More Hours
2007 – 2008	47.2%	9570/54570 17.54%	6180/54570 11.32%	2080/54570 3.81%	410/54570 0.75%	900/54570 1.65%
2011-2012	50.8%	9600/50610 18.97%	6560/50610 12.96%	1410/50610 2.79%	1190/50610 2.35%	440/50610 0.87%

Regional analysis of the number of STEM teachers, the percentage of teachers who reported having ELLs in their overall service load of students, and the mean number of ELLs

teachers had in the years reported was conducted and reported in tables 3-9, 3-10, and 3-11. The

Northeast region was the only region to show an increase in the number of STEM teachers in all

disciplines. The Midwest region was the only region to have a decrease in the total number of

Science teachers, while the other regions all had growth in their total numbers of Science

teachers. The number of Mathematics teachers increased in the Northeast and Midwest while

decreasing in the Southern and Western regions over the same time span. The total number of

Technology teachers decreased in every region except for the Northeast. The percentage of

STEM teachers who indicated having ELLs in their service loads of students increased in every

discipline for every region with the exception of Mathematic teachers in the Midwest. Notably,

of the STEM disciplines in the Midwest, Mathematics teachers had the highest growth in the

average number of ELLs in their service loads. Mathematics teachers had the highest growth of

percentage of teachers with ELLs in their service loads in the Northeast and West regions as

well. Technology teachers had the highest growth in the percentage of teachers with ELLs in

their service loads in the Midwest and had the highest growth of average number of ELLs in

teachers' service loads in the Western region. Comparatively, Science teachers had the highest

growth in the percentage of teachers with ELLs and the highest growth in the average number of

ELLs in service loads in the South.

Table 3-9. Regional Changes in Number of STEM Teachers

	Northeast	Midwest	South	West
Science 2007-08	41480	49710	80600	38730
Science 2011-12	45480	48810	91810	40600
Mathematics 2007-08	55320	54090	119130	51940
Mathematics 2011-12	56230	57550	117050	51170
Technology 2007-08	13050	15301	17540	8690
Technology 2011-12	13950	11580	16930	8150

Table 3-10. Regional Changes in the Percentage of STEM Teachers' serving ELLs

	Northeast	Midwest	South	West
Science 2007-08	41.2%	41.3%	51.6%	72.4%
Science 2011-12	46.6%	43.1%	63.5%	78.5%
Mathematics 2007-08	42.1%	41.3%	52.4%	69.1%
Mathematics 2011-12	52.5%	41.1%	61.8%	80.3%
Technology 2007-08	41.6%	37.0%	48.6%	71.0%
Technology 2011-12	44.3%	43.1%	50.6%	73.3%

Table 3-11. Regional Changes in STEM Teachers' Average Number of ELLs

	Northeast	Midwest	South	West
Science 2007-08	4.78	2.35	3.52	15.64
Science 2011-12	4.61	2.80	7.06	15.15
Mathematics 2007-08	3.80	1.94	4.41	11.68
Mathematics 2011-12	4.24	3.13	4.55	14.35
Technology 2007-08	2.31	2.66	5.87	11.88
Technology 2011-12	5.32	3.35	7.01	18.78

Conclusions and Discussion

The population of English Language Learners in the United States K-12 education system has been growing (Calderón, Slavin, & Sánchez, 2011) and is projected to continue increasing over the upcoming decades (Thomas & Collier, 2001). This growth as well as the current level of ELL inclusion in the K-12 system has led to increasing national focus on this group of learners (Molle, 2013; NCES, 2016). Areas in the United States that have not traditionally had large ELL populations but are now encountering upsurges in their populations of ELLs in schools are increasing focus on the unique needs of this population of students (Cheung, & Slavin, 2012; Pereira, & de Oliveira, 2015). Of particular concern is the need for teachers outside of specialized linguistic courses to adapt instructional methods to better fit the unique needs of

ELLs in their classes (Samson, & Collins, 2012). Although research indicates that educational reforms are falling short in adapting to the growing populations of ELLs nationally (August, Shanahan, & Escamilla, 2009; Ballantyne, Sanderman, & Levy, 2007; Lee, 2005; Menken, & Antunez, 2001) largescale investigations of the nature of teachers' preparedness are largely absent from the literature on this topic. Concurrently, there is an increasing national emphasis on the utility of STEM education in an increasingly technology-laden society and workforce (Bybee, 2010; Marrero, Gunning, Germain-Williams, 2014). The intersection of STEM teachers and ELLs is of particular interest due to the achievement gap between ELLs and their peers in these subjects (DelliCarpini & Alonso, 2014). As such, this exploratory study investigated the preparedness of STEM educators to meet the needs of ELLs through analysis of teachers' credentials and ELL specific professional development participation nationally.

This study utilized data from the 2007-2008 and 2011-2012 SASS TQ datasets to analyze changes in STEM teachers' credentialing in subjects that relate to ELLs, participation in ELL specific professional development activities, and the rates of ELL participation in their overall service loads of students. Regional analysis of ELL participation in the service loads of STEM teachers was also conducted to examine how the ELL populations have grown at different rates between the regions of the United States and the varying STEM disciplines. National analysis showed that for all of the STEM disciplines the percentage of teachers who had ELLs in their classes increased as did the average number of ELLs STEM teachers had in their overall service loads of students. Despite these growths in ELL participation in STEM courses the rates of ELL focused professional development participation for STEM teachers largely stagnated. Although all STEM disciplines showed slight increases in the amount of teachers who participated in these professional development activities, for Science and Math teachers these increases were not

proportional to the overall growth rates of Science and Mathematics teachers which resulted in a slight decrease in the percentage of teacher who took part in these activities. Technology educators were the exception to this finding due to the decrease in the total number of Technology teachers nationally. The fact that the overall number of Technology education teachers that took part in ELL related professional development increased while the number of Technology education teachers decreased could indicate that Technology education programs that are responsive to trends in the student populations are more resilient to cuts in teacher populations.

Data across the four year span between the SASS TQ datasets also showed that of the STEM teachers that participated in these professional development activities the majority took part in eight or less hours of training. Although researchers have supported professional development opportunities as an effective way to bolster STEM teachers' ability to meet the needs of their ELLs (Calderón, Slavin, & Sánchez, 2011; Cheung, & Slavin, 2012), the findings of this study suggest that national engagement in these opportunities has not increased in unison with the growing ELL participation in STEM disciplines. National changes in the credentialing categories of Cultural and Linguistic Degrees and Certifications, as constructed for this study, did show some noticeable growths in certain categories within specific STEM disciplines. However, the findings of this study show that for the STEM disciplines, where large growth occurred over the four year span in in a particular category of credentialing it was not consistent between the disciplines. This could indicate a difference in reactionary credentialing between the disciplines and highlights the notion that these three disciplines operate in separate systems in the larger context of K-12 STEM education. Despite the national focus on STEM education as a unified concept, the lack of uniformity in the credentialing of teachers within each discipline,

indicates a potential separation between the disciplines in approaches to preparing teachers to meet the needs of ELLs. Further efforts to prepare STEM teachers to meet the needs of the growing ELL population in their courses could serve a dual purpose of bringing teachers from these disciplines together as well as providing them with the necessary skills and knowledge to better meet the needs of their students.

Further investigations of STEM teachers' preparedness to meet the needs of ELLs in their courses could benefit from longitudinal analysis over a greater span of time to better examine trends in teacher credentialing, professional development participation, and the growth of ELL participation in STEM courses. Paired with national analysis of these topics more focused investigations could lend insights into how regional policies, industries, and educational initiatives have impacted STEM teachers' involvement in professional development activities and credentialing programs that focus on ELLs. Small-scale analysis could also examine factors that lead to increases in the K-12 ELL population and could be used to preemptively raise teachers' and administrators' awareness of potential ELL population growths in their areas. Corresponding with initiatives to prepare STEM teachers to meet the needs of ELLs should be investigations of research-based techniques that best utilize the unique practices of STEM education to create a learning environment that is suited to encouraging success for all students including ELLs.

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Chapter 4. Conclusion to the Dissertation

This dissertation is comprised of two related quantitative studies which utilize the restricted access national SASS TQ datasets for the 2007-2008 and 2011-2012 schoolyears. These studies aimed to provide clear statistical analysis of the relationship between STEM teachers and the growing ELL population in K-12 education within the United States by examining potential indicators of STEM teachers' preparedness to work with ELLs. The scope of the SASS TQ datasets allowed for a large scale national analysis of this subject. Both of these studies focus on potential indicators of STEM teachers' preparedness to educate ELLs. Although the studies shared this goal they each utilized a different approach to explore this subject. The first manuscript focused on using the most recent dataset to examine this subject nationally and regionally, while the second manuscript utilized two datasets to examine how key factors between STEM teachers and ELLs have changed over time. Both of these studies provide valuable information that frames how the field of STEM education understands the involvement of English Language Learners in their classrooms.

The first manuscript used the most recent SASS TQ dataset to analyze potential indicators of STEM teachers' preparedness to educate ELLs between the STEM disciplines, nationally, and regionally. This level of analysis focused on examining the state of STEM teachers' preparedness as well as comparing and contrasting the selected indicators of preparedness between the STEM disciplines of Science, Mathematics, and Technology. Regional and national analysis provided insights into how levels of STEM teachers' preparedness and the involvement rates of ELLs varies across the United States. STEM teachers' preparedness was analyzed by three major indicators. Those indicators were degrees held, state-level certifications, and ELL specific professional development involvement. Degrees and state-level certifications

were used as indicators of knowledge that was related to educating ELLs. These factors were grouped into focused categories of Linguistics and Culture. This grouping allows for analysis of specific areas of higher credentialing for STEM educators. Regional analysis of STEM teachers' credentialing related to ELLs showed that in regions with higher percentages of STEM teachers with ELLs in their service loads there were also higher percentages of STEM teachers participating in ELL specific professional development across the STEM disciplines.

The second manuscript used the SASS TQ dataset from the 2007-2008 school year as well as the SASS TQ dataset from the 2011-2012 school year to compare factors of STEM teachers' preparedness and ELL involvement in STEM courses across the four year time span. This analysis focused on national changes in STEM teachers credentials related to their preparedness to work with ELLs as well as ELL inclusion in STEM courses. ELL inclusion in STEM courses was observed through the percentage of teachers within a STEM discipline that reported having ELLs in their overall service load of students as well as the average number of ELLs teachers in STEM disciplines reported having. These measures of both frequency and intensity of ELL involvement highlight variances between the STEM disciplines. Analysis of changes in ELL participation in STEM courses showed an increase nationally in the percentage of STEM teachers who had ELLs in their service loads as well as the average number of ELLs STEM teachers had over the four year span. However, analysis of STEM teachers' credentialing related to ELLs showed predominantly stagnation in participation in ELL focused professional development activities. Over the four year time span all of the STEM disciplines had slight increases in the total number of teachers within the discipline that took part in these professional development activities, but only Technology education had an increase in the percentage of

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teachers taking part in these activities and that change in percentage was directly linked to the decrease in the overall number of Technology educators nationally.

Comparing findings from both studies allows for more insight into the nature of the relationship between STEM educators' preparedness to work with ELLs and the growing ELL participation in STEM courses nationally. Regional analysis from the first manuscript shows that in regions that had higher percentages of STEM teachers with ELLs in their service loads there were also higher percentages of STEM teachers participating in ELL specific professional development. However, findings from the second manuscript show that nationally as the percentages of STEM teachers with ELLs in their service loads rose there was no substantial rise in STEM teacher participation in the related professional development activities.

Currently researchers have stated that teachers outside of specialized linguistic courses in the K-12 education system are not well prepared to meet the needs of the growing population of ELLs (August, Shanahan, & Escamilla, 2009; García, Arias, Harris, & Serna, 2010). These exploratory studies isolate STEM teachers to examine their credentialing related to ELLs and the involvement of ELLs in their courses in an effort to better frame analysis of this relationship nationally, regionally, and over time. Findings from these investigations give support to the ongoing push for STEM teachers to be aware of and responsive to the needs of the ELLs in their courses. These findings also show that the prevalence of ELLs in STEM courses is rising nationally both in intensity and frequency as measure by percentage of STEM teachers with ELLs in their service loads and the average number of ELLs in those service loads. These rises add credibility to calls for increased attention to the needs of this population of learners through targeted support for STEM teachers.