K-12 STEM Educators and the Inclusive Classroom

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Education

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May 3, 2016
Blacksburg, VA

Keywords: STEM education, School and Staffing Survey Teacher Questionnaire, students with disabilities, Limited English Proficiency, teacher professional development, teacher satisfaction and retention

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ABSTRACT

The United States public schools promote inclusion and educational equity among diverse student populations. Considerable and growing numbers of students with categorical disabilities and Limited English Proficiency (LEP) are enrolled in regular classrooms. The systemic barriers in learning that they have could impact teacher perceptions and decisions about teaching practices as well as the teaching profession. These students have challenged K-12 science, technology, engineering, and mathematics (STEM) teachers to provide high-quality, accommodative service and equitable educational opportunities in an increasingly STEM-infused society. Professional development associated with teaching students with disabilities and LEP is critical to inform in-service STEM teachers with these students' learning needs and promote student success. Effective preparation and support help maintain teacher satisfaction and retention within the teaching profession. However, the levels and perceptions of STEM teacher participation in such professional development, and whether the service load and professional development regarding the concerned groups of students associated with teacher satisfaction and retention remain unclear.

This dissertation addresses these issues through two research studies using secondary analysis of the 2011-2012 School and Staffing Survey Teacher Questionnaire (SASS TQ) national dataset. The first study focused on K-12 STEM educator participation and perceived utility regarding their professional development experience concerning students with disabilities and LEP. Quantitative analysis revealed an overall lower level of participation and perceived utility of such professional development for STEM educators compared to all other educators. The second study examined teacher satisfaction and intent to remain in teaching, as well as their relationships to teacher service load and professional development specific to students with disabilities and LEP. Results indicated that K-12 STEM educators were less likely to feel satisfied or intent on remaining in teaching, compared to the remainder of the teaching population. Logistic regressions showed that service load of students with LEP predicted teacher satisfaction and participation in professional development concerning students with disabilities associated with teacher intent to remain in STEM education, especially for science educators. These findings collectively suggested the necessity and demands of sufficient and useful professional development offerings regarding the two concerned groups of students in inclusive STEM education settings.

Dedication

To my husband and best friend, Zhang Xuning, who trusted, encouraged, and supported me every step of the way.

To my baby boy, August H. Zhang, who challenged me to grow into a stronger person than I thought I could be.

To mom and dad, Yang Fengqin and Li You, who rearranged their life to make it happen.

To all my family, friends, and colleagues who encouraged or inspired me to go through it.

Last but not least, to my dear Deedy and Tangtang, who always accompanied when I worked during dark nights.

Acknowledgements

I would like to thank the many people who supported me in the writing of this dissertation.

To Dr. Jeremy Ernst, my committee chair, academic adviser, supervisor, and co-author of the manuscripts in my dissertation, who gave me the opportunity and supported me to pursue this degree, and guided me to develop research skills through every single conversion and task. I feel extremely fortunate to have worked with you, advised by you, and learned from you during the past four years. To my committee member and co-author of the manuscripts, Dr. Thomas Williams, who dedicated time to help me access and get acquainted with the dataset and instrument, and provided insightful comments and valuable contribution to the research. To my committee members, Dr. Kusum Singh and Dr. Anne Driscoll, who offered excellent insight on research methodologies and data analysis, and provided ongoing guidance and feedback to my dissertation. The support and encouragement from all of you truly benefited my professional growth and scholarly development.

I also would like to thank all my professors and colleagues at Virginia Tech, who helped me build content knowledge foundations, develop research and analysis abilities, and get accustomed to the scholarly life at Virginia Tech.

Thank you to the Laboratory for Interdisciplinary Statistical Analysis (LISA) program for assistance on statistical issues in my research.

Finally, thank my husband Zhang Xuning and all my family members, for your unyielding love and support.

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Attribution

Songze Li (SL) is the primary author of this dissertation. The two manuscripts included in this dissertation are collaborative work of three authors. The first manuscript presented in Chapter 2 is a published journal article co-authored by Songze Li, Dr. Jeremy V. Ernst (JVE), and Dr. Thomas O. Williams (TOW). The workload allocation is described as follows:

> The primary author SL proposed the research idea, designed the study, wrote the bulk of the manuscript, prepared the charts and tables, and participated in all stages of development as well as being the primary person to respond to reviewer questions and complete manuscript revisions. JVE contributed to the conclusions, the literature review and development, and framing the research questions, editing, and answering reviewer questions. TOW contributed to IES [Institute of Education Sciences] data approval process, data acquisition, data analysis, methods and results, and editing and answering reviewer questions. (Li, Ernst, & Williams, 2015, see "Declarations" in Chapter 2 for authors' contributions).

The research presented in Chapter 3 was conducted by the same research group. SL took the primary work in study design, IRB (Institutional Review Board) acquisition, data analysis, manuscript composition, charts and table preparation. JVE contributed to framing the research questions, improving the writing, and discussion of results and conclusions. TOW contributed to the IES data approval process, data acquisition, data screening, and results reviewing. When eventually submitted for publication, all will contribute to improving the quality of the written manuscript and answering reviewer questions, and all will be co-authors on the study.

Chapter 1. Introduction to the Dissertation

Background

The United States is considered as one of the most diverse countries in the world. As a projection of the future landscape of the human resource within the United States, the U.S. public school system promotes inclusion and educational equity among diverse student populations. The Individuals with Disabilities Education Improvement Act (IDEA) of 2004, mandates a free and appropriate public school education for all children and youth with disabilities and requires that these students with disabilities be educated in general classrooms to the greatest extent appropriate. There has been reported that 6.4 million, or 13 percent of public school students received special education services during the 2012-13 school year (National Center for Education Statistics [NCES], 2015a). Almost all of these students had learning experiences in general classes. The enrollment of school-age children and youth served under IDEA in the 2012-13 school year is presented in Figure 1-1. The national data showed that 95 percent of school-age children and youth served under IDEA were enrolled in regular schools, and the majority of them spent 80 percent or more time within general classes (NCES, 2015a). This indicated that many school teachers had students with disabilities in their regular class.

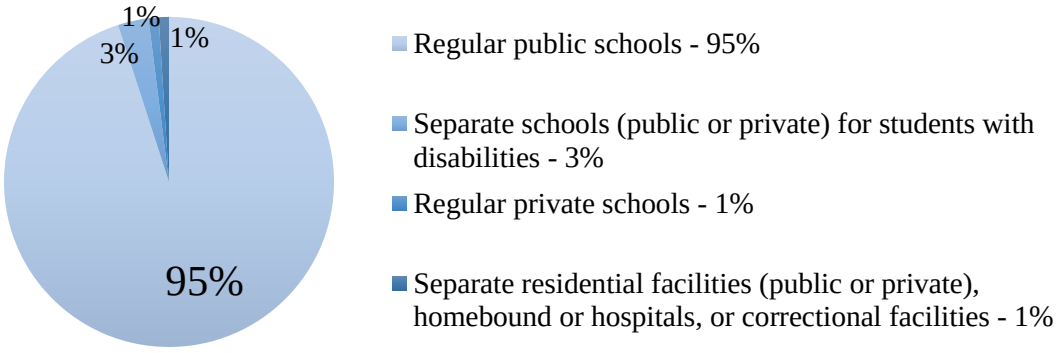

Figure 1-1. Enrollment of school-age children and youth ages 6-21 served under IDEA in the 2012-13 school year. Data retrieved from "Children and Youth With Disabilities" by National Center for Education Statistics, 2015a, in The Condition of Education 2015.

IDEA identified a list of 13 categories of disabilities for children and youth ages three through twenty-one to receive protections and services: 1) autism; 2) deaf-blindness; 3) deafness; 4) emotional disturbance; 5) hearing impairment; 6) intellectual disability; 7) multiple disabilities; 8) orthopedic impairment; 9) other health impairment; 10) specific learning disability; 11) speech or language impairment; 12) traumatic brain injury; and 13) visual impairment (including blindness) (National Dissemination Center for Children with Disabilities, 2012). These categories do not include students who speak a foreign language but have linguistic barriers in English.

Immigrants bring their cultures and languages to this country. The U.S. Census Bureau (2015) reported that there are over 350 languages spoken in United States homes. Linguistic diversity has changed rapidly in the United States during the past decades. The number of people speaking a language other than English at home increased by 158.2 percent nationwide from 1980 to 2010 (Ryan, 2013). More recently released data from 2013 Census Bureau American Community Survey (ACS) showed that the number has reached 61.8 million, constituting one fifth of the United States population, and about 41 percent among them or 25.1 million people were categorized as individuals with Limited English Proficiency (LEP). Children raised in these families may have relatively low proficiency in English. In 1990, 6.3 million students between ages five to seventeen spoke a language other than English, and nearly 2.4 million spoke English with difficulty (NCES, 1994). In the school year 2012-13, there were estimated 4.4 million or 9.2 percent of public school students identified as English language learners (ELLs). The number of students with LEP nearly doubled during the two decades (see Figure 1-2) while the total public school enrollment only increased about 20% during the meantime (NCES, 2015b). Every state

had ELLs for public schools enrollment, from the lowest percentage at 0.7 percent in West Virginia to the highest at 22.8 percent in California (NCES, 2015c).

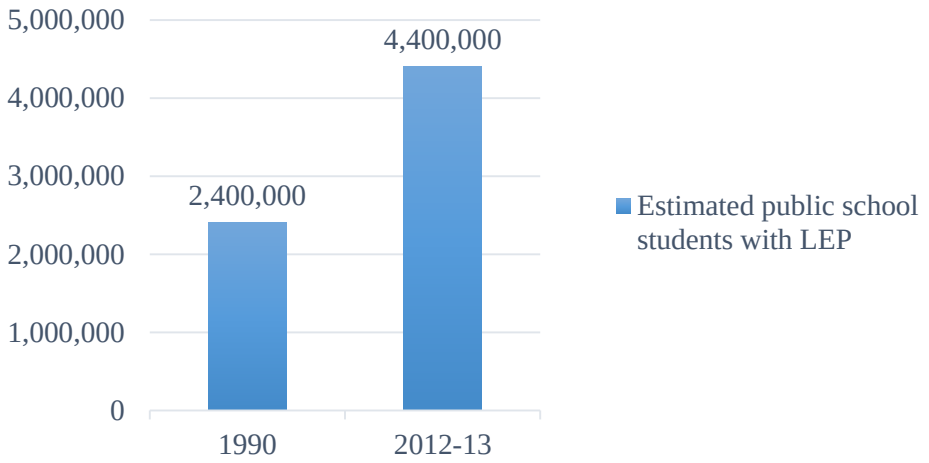

Figure 1-2. Public school students with LEP in 1990 and 2012-13. Data retrieved from "The Condition of Education 1994", by National Center for Education Statistics, 1994, and "English Language Learners" by National Center for Education Statistics, 2015c, in The Condition of Education 2015.

Students who have linguistic barriers are commonly substantially disadvantaged in school and categorized as at-risk students (Levinson, Cookson, & Sadovnik, 2014). There are various criteria to define students who are not proficient in English at national and state levels for demography, program eligibility, and other purposes (Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997). In the current series of studies, students of LEP or ELLs are defined as "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, 2011, p. 10).

Conceptual Framework

Students with disabilities and LEP often have systemic barriers to engage in class activities (Newman et al. 2011). Students with disabilities usually have trouble in receiving and expressing knowledge that is presented in formats conventionally used in classrooms. This is similar for students with LEP, the language and cultural barriers may hinder them from

understanding instruction or accomplish academic tasks (Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997). These students need adaptive instruction or accommodation that match their backgrounds and demands, through which their learning outcomes could be improved (Wang, 1980; Leiding, 2009).

A growing body of research has revealed that teachers serve critical roles in student learning achievement (Stronge, 2002). Teachers in the United States are facing evolving classroom situations. Student population composition is becoming more inclusive and increasingly challenging to classroom teachers than ever before. Students with disabilities and LEP, who are conventionally underserved and generally less accomplished in STEM education, deserve equitable educational experiences (Thurlow, Bremer, & Albus, 2011; Guevara, 2014). The students in these two specified subgroups may have learning needs different from the general student population in STEM education, and usually require customized teaching strategies (Shifter & Callahan, 2010; Newman et al., 2011; Burgstahler, 2011; Leiding, 2009). High-quality STEM teachers are needed in the field to provide high-quality services to meet student's individual educational needs and prepare these students for the increasingly STEM-infused society and the growing opportunities in STEM careers in the United States.

However, the shortage of high-quality STEM teachers is a severe issue in the United States (U.S. Department of Education, 2015). Teacher attrition is one of the major reasons of lack of qualified teachers in STEM classrooms. STEM teachers who work with students with disabilities and LEP may have to make extra efforts but receive low outcomes since these groups of students tend to disengage and underachieve in academic activities in an inclusive classroom. Such situations may impact teacher perception on their competence, lead to a low satisfaction, and drive them to leave the field. Although students have important roles in influencing teacher

intention to leave, there is limited research linking students to teacher retention (Johnson, Berg, & Donaldson, 2005).

To provide high-quality service and address individual learning needs, teachers should have knowledge about their students and pedagogical strategies specifically applied in the subjects that they teach (Shulman, 1986). In-service teachers can develop the necessary knowledge and strategies through professional development that addresses their current classroom issues. Research has shown that teacher professional development boosted student learning outcomes in STEM education (Crippen, Biesinger, & Ebert, 2010). Professional development can also increase teachers' perceived competence by "building their capacity and will to succeed with the diverse learners in their classrooms" (Johnson, Berg, & Donaldson, 2005, p. 81). Programs that support teachers who work with diverse populations have been widely implemented, however, limited research has been done to provide a national overview on the levels and perceptions of STEM teacher participation in professional development specific to students with disabilities and LEP, or to explore the relationship between participation in these professional development experiences and teacher retention.

Educational researchers have suggested future research to investigate the effect of training and retraining programs for teachers serving diverse student groups on teacher satisfaction and retention (Johnson, Berg, & Donaldson, 2005; Stempien & Loeb, 2002). Specifically, given that in K-12 STEM education teachers have generally higher turnover and students with disabilities and LEP are traditionally at a disadvantage, investigations should be launched to explore the status of STEM teacher service load and professional development concerning these students, and the potential influence on their satisfaction and retention. The conceptual framework is summarized and presented in Figure 1-3.

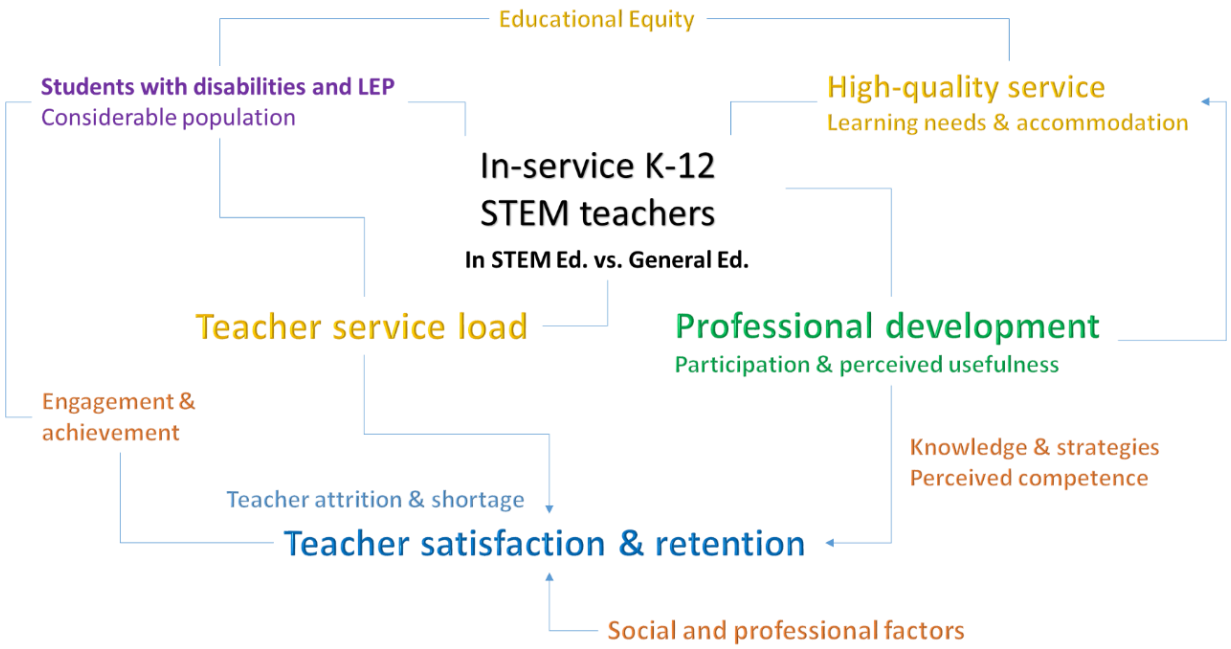

Figure 1-3. Conceptual framework

Overview of the Dissertation

This dissertation research consists of a series of two separate but closely relevant research studies concerning in-service public school STEM teachers in the United States. The research studies employed secondary analyses on the national restricted dataset of the 2011-12 School and Staffing Survey Teacher Questionnaire (SASS TQ). The first study in the series focused on K-12 STEM educator participation and perceived utility regarding professional development associated with teaching students with disabilities and LEP. Teacher participation and perceived utility regarding the specified professional development were categorically summarized and compared between STEM and the remainder of teaching populations, as well as across science, technology, and mathematics disciplines.

The second study addressed STEM teacher satisfaction and retention within an inclusive context. Test of independence was used to detect the differences between STEM and all other teachers regarding their job satisfaction (the first dependent variable) and intent to remain (the

second dependent variable). Logistic regressions were employed to examine the relationships between teacher satisfaction and teacher service load and professional development concerning students with disabilities and LEP (the independent variables), as well as between teacher intent to remain and the independent variables. The regression analysis was conducted and compared among STEM, science, mathematics, technology, and all other teacher subgroups.

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Chapter 2. Manuscript One

Supporting students with disabilities and limited English proficiency: STEM educator professional development participation and perceived utility

Songze Li, Jeremy V. Ernst, and Thomas O. Williams

Abstract

Background
Professional development offerings assist K–12 educators in addressing new and evolving classroom dynamics, circumstances, and situations. With the emerging demands of an increasingly science, technology, engineering, and mathematics (STEM)-infused society, teachers are challenged to provide high-quality service and equitable educational opportunities to all STEM education students, particularly to those students who traditionally are underrepresented in comparison to their peers in STEM education and/or have aspirations of participation in STEM-related careers. This study investigated K–12 STEM educator participation and perceived utility regarding professional development addressing specific needs of students with identified categorical disabilities and limited English proficiency (LEP).

Results
Collection and analysis methods employed data retrieval and tabulation from the 2011–2012 School and Staffing Survey (SASS) Teacher Questionnaire (TQ). The national restricted access dataset was used to identify targeted teacher populations as well as provide a profile of STEM teacher participation in practice-oriented professional development activities regarding the two specified student groups. The results were categorically summarized and compared across science, technology, and mathematics (STM) disciplines and also between STM educators, non-STM educators, and educators in general.

Conclusions
The results indicated that STM teachers tended to engage in fewer professional development opportunities and dedicated fewer hours in the professional development regarding students with categorical disabilities and LEP than the remainder of the teaching population. Overall, STM teachers' perceived utility of the provided professional development experience was lower than that of the remainder of the teaching population.

Keywords
STEM education, School and Staffing Survey Teacher Questionnaire, Students with disabilities, Limited English proficiency, Teacher professional development

Background

Science, technology, engineering, and mathematics (STEM) educators in the US are working with increasingly inclusive student populations, including students with categorical disabilities and limited English proficiency (LEP). A list of 13 categorical disabilities have been identified for individuals ages 3 through 21 years old by the Individuals with Disabilities Education Act (2012), including (1) autism, (2) deaf-blindness, (3) deafness, (4) emotional disturbance, (5) hearing impairment, (6) intellectual disability, (7) multiple disabilities, (8) orthopedic impairment, (9) other health impairment, (10) specific learning disability, (11) speech or language impairment, (12) traumatic brain injury, and (13) visual impairment (including blindness). The federal term "LEP" represents a group of students primarily speaking languages other than English. These students are also referred to as "English language learners (ELLs)" and "emergent bilingual (EB)" by educators (García, 2009).

K–12 STEM educators are expected to inform STEM learning and encourage pursuit of future STEM education and careers. However, Newman et al. (2011) identified that less than 9 % of undergraduate university students with disabilities reported majors in engineering and only 6 % reported majors in either science or computer-related areas. Resultant of global discovery and development, the effectiveness of STEM education is important for national wealth and welfare in the future (President's Council of Advisors on Science and Technology (US), 2010). STEM education helps prepare citizens to make informed decisions and adapt to life and work in an increasingly technological world. However, students with disabilities and LEP often have systemic barriers to engagement (Newman et al., 2011) and are consequently less likely to pursue STEM majors or careers. Although there is a growing job market in STEM-related areas, for undetermined reasons, these groups of students are less likely to participate. Post-educational

career prospects for these students can be enhanced through accessible and meaningful STEM education opportunities. Student STEM educational experiences in secondary education influence pursuit of STEM-related careers (Yu et al., 2012). Equitable access to these experiences would prospectively encourage these traditionally underrepresented students (students with disabilities and students with LEP) to choose STEM majors and, subsequently, future careers.

It is imperative that students with LEP receive quality STEM educational experiences where practitioners are not only equipped to address specific educational needs but position themselves within an advocacy role (Zehr, 2010). Similarly, STEM practitioners are expected to individualize and differentiate instruction to build meaningful learning experiences for students with disabilities (Sotomayer, 2013). Genuine understanding and informed advocacy are also central features in ensuring access for learners while enhancing preparations to maximize learner outcome (Goeke & Ciotoli, 2014). Capacity building opportunities for teachers traditionally come in the form of professional development offerings. Professional development opportunities may not provide prescribed context for curricula but help teachers transfer knowledge into instructional practice (McCutchen et al., 2002). "Enhancing the quality … of K–12 STEM education is inextricably linked to the continued professional development of K–12 teachers" (Nadelson et al., 2012, p. 69). Podhajski et al. (2009) indicate that effective professional development has a positive influence on students' scientific-associated abilities. Nimisha et al. (2012) found that professional development engaging teachers with useful pedagogy in mathematics solidified teacher's familiarity with such strategies. Further, quality professional development improves teacher skills of identifying and addressing student misconceptions, as well as improving teacher pedagogical content knowledge.

Epistemological and pedagogical teacher conceptions, paired with professional practical knowledge, are core factors of teacher learning experiences that enable the transformation of research into practice (Rivero et al., 2011). With the vast array of content-based professional opportunities, a low level of practice-based engagement in professional development for STEM educators persists. Teacher classroom practices, reflecting pedagogical content knowledge and knowledge of learners, are very important. Even short-term professional development can significantly impact educators' attitudes, preparedness, and responsiveness to students with disabilities (Rule et al., 2011). Exemplary teacher learning and professional development models have been identified to promote notable successes with students with disabilities or LEP (Burgstahler & Doe, 2004; Lee et al., 2004). However, many professional development opportunities operate without identifiable evidence-based frameworks (Schumm & Vaughn, 1995; Avalos, 2011).

As classrooms become more inclusive, many teachers will need to provide additional accommodations for students with disabilities and LEP. Professional development can influence teacher's perspectives and practices in STEM teaching and narrow the achievement gaps between the two concerned student groups and the remaining student population (Lee et al., 2008; Hart & Lee, 2003; Gándara, 2006). On the other hand, teachers' perceptions of professional development could mediate teaching practice and inform on-going and future professional development offerings (Lee et al., 2008). In addition, the focus of the STEM educational shift for students with disabilities and LEP is in a gradual transition from an exclusive subject content knowledge focus to the development of associated reasoning and problem-solving skills (Crippen & Archambault, 2012), providing a direction and charge for a new classroom context. Provided the emerging trajectory of STEM education professional

development based on new learner needs and societal demands, further targeted offerings are necessary. However, levels and perceptions of meaningful STEM educator participation in professional development specific to students with disabilities and LEP are currently unclear from a national perspective. To explore the professional development status issue, an investigation was designed, coordinated, and implemented.

Research Questions

This investigation was guided by five research questions associated with STEM educator participation in professional development specifically crafted to address needs of students with disabilities and LEP. The guiding questions are as follows:

(1) What level of participation in professional development opportunities, centered on educating students with disabilities, do K–12 STEM educators demonstrate?

(2) What level of participation in professional development opportunities, centered on educating students with limited-English proficiency, do K–12 STEM educators demonstrate?

(3) Do STEM educators find professional development participation (students with disabilities and LEP) useful?

(4) Does degree of professional development participation (students with disabilities and LEP) vary based on STEM education discipline?

(5) Does degree of professional development participation (students with disabilities and LEP) vary between STEM educators and all other classifications of educators?

These questions are explored through variable isolation of the Schools and Staffing Survey (SASS) where frequency and summary analyses were conducted. Questions were investigated through summation of data and presented in frequency-based and proportional formats.

Instrumentation

This study employed SASS, a system of related questionnaires, as the instrument. Tourkin et al. (2010, p. 8–9) concisely identified the SASS instrumentation purpose and procedure:

> The SASS is conducted by the National Center for Education Statistics (NCES) on behalf of the US Department of Education in order to collect extensive data on American public and private elementary and secondary schools. The 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. SASS is a large-scale sample survey of K–12 school districts, schools, teachers, library media centers, and administrators in the USA.
>
> The SASS was designed to produce national, regional, and state estimates for public elementary and secondary schools and related components (e.g., schools, teachers, principals, school districts, and school library media centers); national estimates for BIE-funded and public charter schools and related components (e.g., schools, teachers, principals, and school library media centers); and national, regional, and affiliation strata estimates for the private school sector (e.g., schools, teachers, and principals). Therefore, the SASS is an excellent resource for analysis and reporting on elementary and secondary educational issues.

The sampling method of SASS permits a population analysis on a representative sample in the United States, as described on the SASS website:

> The SASS uses a stratified probability sample design to ensure that the samples of schools, principals, teachers, districts, and school library media centers contain sufficient

numbers for reliable estimates. Public and private schools are oversampled into groups based on certain characteristics. After schools are stratified and sampled, teachers within the schools are also stratified and sampled based on their characteristics (NCES, n.d., "Sample selection").

The SASS consisted of five sets of questionnaires: School District Questionnaires, Principal Questionnaires, School Questionnaires, Teacher Questionnaires, and School Library Media Center Questionnaires. The Teacher Questionnaires include the Teacher Questionnaire (SASS TQ) for public school teachers and Private School Teacher Questionnaire. This study employed data retrieved from 2011–2012 SASS TQ to answer research questions. SASS TQ obtained information about teachers, consisting of the following sections: (1) general information, (2) class organization, (3) education and training, (4) certification, (5) professional development, (6) working conditions, (7) school climate and teacher attitudes, (8) general employment and background information, and (9) contact information.

This study examines practice-oriented professional development, specifically referring to professional development regarding students with categorical disabilities and LEP, in the 2011–2012 school year. Question 48a, "In the past 12 months, have you participated in any professional development on how to teach students with disabilities?" (yes or no), question 48b, "In the past 12 months, how many hours did you spend on these activities?", and question 48c, "Overall, how useful were these activities to you?" were adopted to describe the status of teacher professional development regarding students with categorical disabilities.

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)?" (yes or no), question 49b, "In the past 12 months, how many hours did you spend on

these activities?", and question 49c, "Overall, how useful were these activities to you?" were adopted to describe the status of teacher professional development regarding students with LEP.

The level of participation in practice-oriented professional development was measured by questions 48b and 49b, regarding teaching students with disabilities and LEP, respectively, on a four-level ordinal scale from "8 hours or less," "9–16 hours," "17–32 hours," to "33 hours or more." Teachers' perception of these professional development experiences was measured by questions 48c and 49c on a four-level ordinal scale including "not useful," "somewhat useful," "useful," and "very useful."

Participant Description

The target population for this study was K–12 science, mathematics, and technology teachers in the public school systems of the USA. The groups were defined by the responses to SASS TQ question 16, "This school year what is you MAIN teaching assignment at THIS school?" Teachers who responded with codes 211, 212, 213, 217, or 210 (biology or life sciences, chemistry, earth sciences, physics, and other natural sciences) were identified as science teachers. Teachers who responded with codes 191, 192, 193, 194, 195, 196, 198, 199, 200, or 201 (algebra I, algebra II, algebra III, basic and general mathematics, business and applied math, calculus and pre-calculus, geometry, pre-algebra, statistics and probability, and trigonometry) were identified as mathematics teachers. Those who were identified as technology teachers responded with codes 246, 249, 250, or 255 (construction technology, manufacturing technology, communication technology, and general technology education). Demographic information regarding the race and gender of the participants was also tabulated by subject in Table 2-1 and visualized in Figure 2-1.

Table 2-1. Teacher demographics by subject

		Mathematics	Science	Technology	All others
Total number		281,990	226,700	50,610	2,825,880
Gender (*n* (%))	Male	98,050 (34.8)	86,520 (38.2)	38,150 (75.4)	578,910 (20.5)
	Female	183,940 (65.2)	140,170 (61.8)	12,460 (24.6)	2,246,980 (79.5)
Race (*n* (%))	White	246,310 (87.3)	201,770 (89.0)	46,520 (91.9)	2,552,240 (90.3)
	Black	23,330 (8.3)	15,750 (6.9)	2410 (4.8)	2,155,670 (7.6)
	Asian	11,920 (4.2)	8780 (3.9)	1140 (2.3)	53,230 (1.9)
	Pacific Islander	850 (0.3)	1260 (0.6)	250 (0.5)	8990 (0.3)
	American Indian	3260 (1.2)	3280 (1.4)	1370 (2.7)	40,730 (1.4)
	Hispanic	18,270 (6.5)	14,420 (6.4)	3560 (7.0)	227,870 (8.1)

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

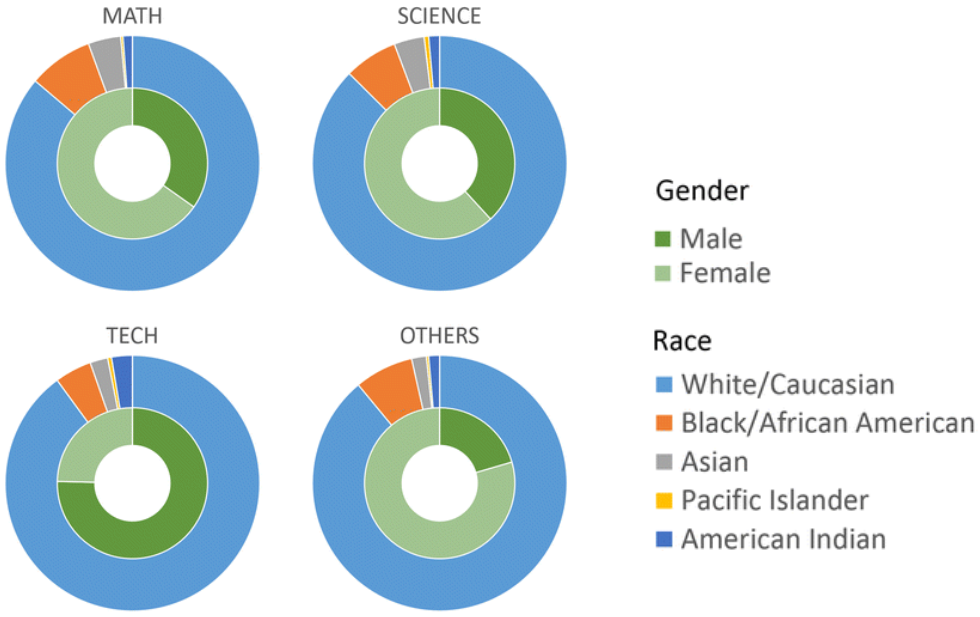

Figure 2-1. Teacher demographics by subject

The service load of secondary educators pertaining to education of students having a categorical disability or LEP for the 2011–2012 school year was gauged by the SASS TQ datasets. The teacher service load, which indicated the number of students taught during the school year, was described in Table 2-2 and Figure 2-2 by subject.

Table 2-2. Teacher service load by subject

		Mathematics	Science	Technology	All others
Categorical disabilities	Mean	9.84	13.41	18.87	11.25
	Std. D.	10.566	14.261	25.123	17.425
	Median	7	10	12	5
	Range	100	126	231	483
	Maximum	100	126	231	483
LEP	Mean	5.98	7.1	7.6	7.28
	Std. D.	12.899	15.892	20.236	25.231
	Median	1	1	1	1
	Range	170	185	200	700
	Maximum	170	185	200	700

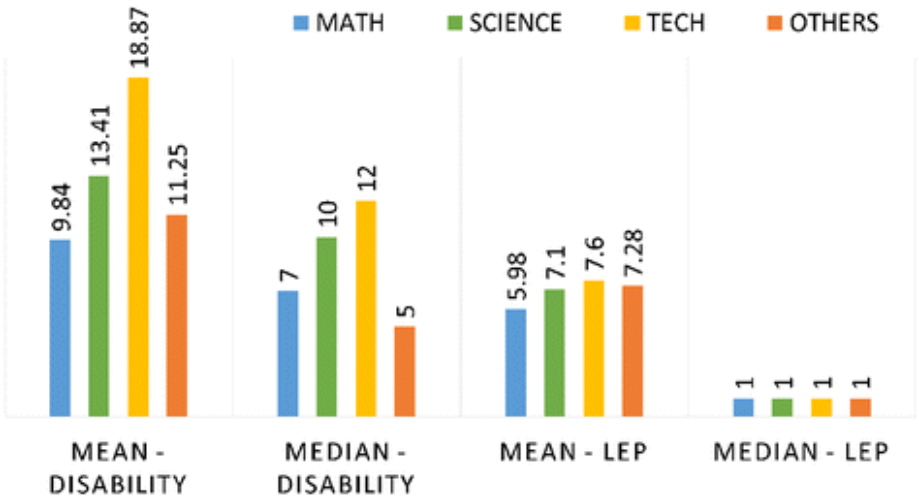

Figure 2-2. Teacher service load by subject

Methods

This study conducted a secondary analysis of the SASS TQ dataset administered by the NCES. Initial access to this dataset was authorized by the NCES to Virginia Tech. A member of the research team was provided designated single-site user admittance to this dataset. As per the restricted access agreement, specific protocol and reporting information was submitted. After review, the NCES authorized approval and release of the frequency and summary analyses.

For the 2011–2012 SASS TQ, there were 3,385,170 instances within the weighted results. The NCES and IES require that all weighted *n*'s be rounded to the nearest 10 for SASS to assure

participant anonymity. Therefore, data in the tables and narrative may not add to the total N reported due to rounding requirements.

The five research questions were explored in this study in terms of teacher professional development participation concerning students with disabilities and LEP. For the purpose of analyses, science, technology, and mathematics (STM) educators and non-STM educators were categorically summarized and compared. The results of STM educators were also analyzed across these three disciplines. The primary variables of interest in this study were the time dedicated by teachers and their perceived utility of the practice-oriented professional development. Following methodological considerations from the study of Ernst et al. (2014, p. 4), "the number of categorized students served was determined by responses from teachers who reported teaching students with recognized disabilities requiring an individualized education plan. The number of students identified as LEP was determined by responses from teachers who reported teaching students who did not speak English as their primary language and who had a limited ability to read, speak, write, or understand English." Data from the 2011–2012 SASS TQ were extracted and analyzed using descriptive statistics.

Results and Discussion

The number of valid cases for this study was 3,385,170. Self-reported demographic information and teacher service load are summarized in Tables 2-1 and 2-2. Information concerning participation level in professional development centered on educating students with disabilities are summarized in Tables 2-3 and 2-4 and presented visually in Figures 2-3 and 2-4. Descriptive analysis showed that STM teachers, especially science and technology teachers, had higher chance to serve students with disabilities based on sample means and medians. However, of all the defined STM teachers, only 30.52 % participated in practice-oriented professional

development regarding students with disabilities, which was much lower when compared to 38.78 % of non-STM teachers. Among the teachers who participated, technology teachers had highest service load regarding students with disabilities. Concurrently, they reported a highest percentage in terms of time dedicated in professional development for 33 or more hours associated with students with disabilities. This percentage was about three times that of science and mathematics teachers and higher than that of non-STM teachers. Table 2-5 and Figure 2-5 show teachers' perception of such professional development by subject. There were 20.36 and 45.11 % technology teachers reporting that such professional development was very useful or useful to them; in contrast, only 14.39 and 38.50 % of science teachers reported that this type of professional development was very useful or useful. Although science teachers also reported relatively high service load as technology teachers did, their time dedicated in and perceived utility of these professional development activities were even lower than non-STM teachers.

Table 2-3. Participation in professional development regarding students with categorical disabilities (question 48a)

Area	Yes *n* (%)	No *n* (%)	Total
Mathematics	85,020 (30.15)	196,970 (69.85)	281,990
Science	68,630 (30.27)	158,070 (69.73)	226,700
Technology	17,070 (33.73)	33,540 (66.27)	50,610
Total STM	170,710 (30.52)	388,580 (69.48)	559,290
All others	1,095,950 (38.78)	1,729,930 (61.22)	2,825,880
Total	1,266,660 (37.42)	2,118,510 (62.58)	3,385,170

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

Table 2-4. Time dedicated in professional development regarding students with categorical disabilities (question 48b)

Area	≤8 h *n* (%)	9–16 h *n* (%)	17–32 h *n* (%)	≥33 h *n* (%)	Total
Mathematics	65,290 (76.80)	13,250 (15.58)	3980 (4.69)	2500 (2.93)	85,020
Science	50,720 (73.90)	11,580 (16.88)	4430 (6.45)	1900 (2.77)	68,630
Technology	12,600 (73.82)	2140 (12.53)	780 (4.59)	1550 (9.06)	17,070
Total STM	128,610 (75.34)	26,970 (15.80)	9190 (5.39)	5940 (3.48)	170,710
All others	719,640 (65.66)	195,820 (17.87)	103,030 (9.40)	77,460 (7.07)	1,095,950
Total	848,250 (66.97)	222,780 (17.59)	112,230 (8.86)	83,400 (6.58)	1,266,660

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

Table 2-5. Perceived utility of professional development regarding students with categorical disabilities (question 48c)

Area	Not useful *n* (%)	Somewhat useful *n* (%)	Useful *n* (%)	Very useful *n* (%)	Total
Mathematics	5370 (6.31)	31,690 (37.28)	32,540 (38.28)	15,420 (18.13)	85,020
Science	5050 (7.36)	27,280 (39.75)	26,420 (38.50)	9870 (14.39)	68,630
Technology	940 (5.50)	4960 (29.03)	7700 (45.11)	3480 (20.36)	17,070
Total STM	11,360 (6.65)	63,930 (37.45)	66,660 (39.05)	28,760 (16.85)	170,710
All others	38,190 (3.48)	297,880 (27.18)	504,560 (46.04)	255,330 (23.30)	1,095,950
Total	49,540 (3.91)	361,810 (28.56)	571,220 (45.10)	284,090 (22.43)	1,266,660

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

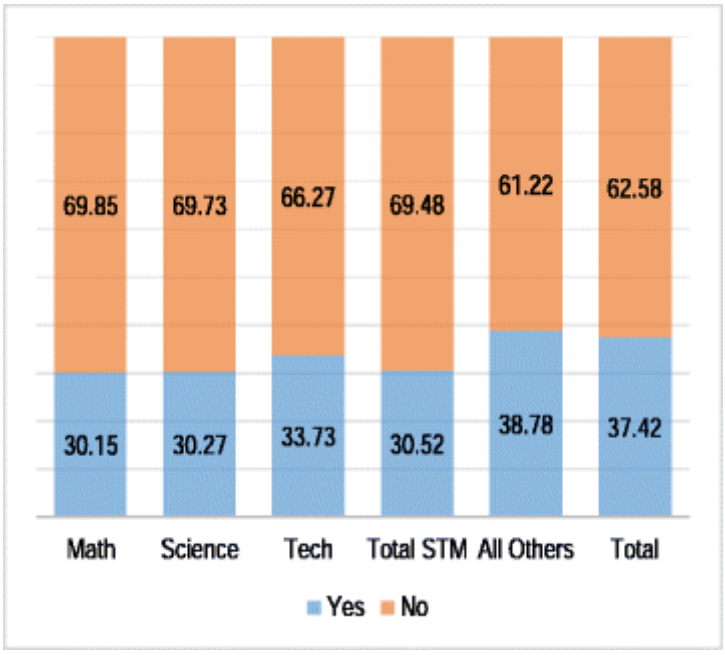

Figure 2-3. Participation in professional development regarding students with categorical disabilities (question 48a)

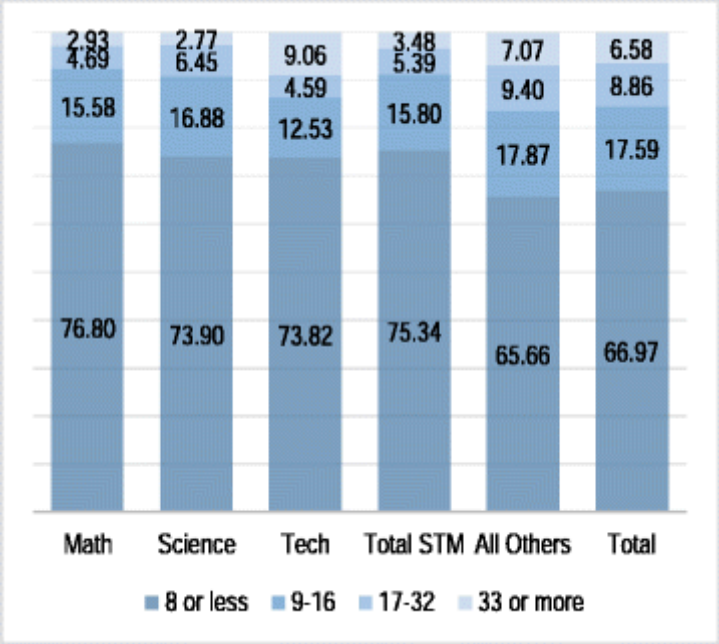

Figure 2-4. Time dedicated in professional development regarding students with categorical disabilities (question 48b)

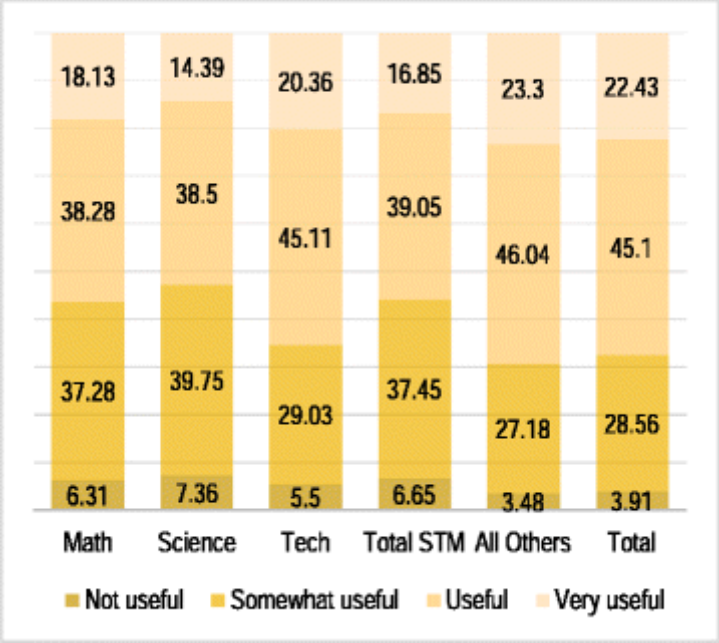

Figure 2-5. Perceived utility of professional development regarding students with categorical disabilities (question 48c)

According to the results about participation level in professional development centered on educating LEP students shown in Tables 2-6 and 2-7, less than 20 % of the technology teachers reported that they participated in professional development on how to teach LEP

students, which is the lowest among STM and non-STM teachers, although technology teachers reported highest mean service load on students with LEP. Compared to non-STM teachers, more STM teachers dedicated 8 hours or less in such professional development, and a lower percentage of STM teachers reported 9–16 hours, 17–32 hours, and 33 hours or more. Table 2-8 shows the teachers' perception of such professional development by subject. About 64 % of the non-STM teachers reported that the professional development experience toward education LEP students was useful or very useful, while only half of the STM teachers were classified in the same categories. Technology teachers had the highest proportion in reporting the professional development regarding LEP students was very useful, followed by non-STM teachers. Mathematics teachers had the least proportion to confirm the utility of such professional development and the most proportion in considering it not useful. This pattern was in accordance with the teacher-reported LEP service load by subject. Figures 2-6, 2-7, and 2-8 provide graphic representation of the results associated with LEP students.

Table 2-6. Participation in professional development regarding students with LEP (question 49a)

Area	Yes *n* (%)	No *n* (%)	Total
Mathematics	69,970 (24.81)	212,020 (75.19)	281,990
Science	53,010 (23.38)	173,690 (76.62)	226,700
Technology	9600 (18.97)	41,010 (81.03)	50,610
Total STM	132,570 (23.70)	426,720 (76.30)	559,290
All others	773,350 (27.37)	2,052,530 (72.63)	2,825,880
Total	905,920 (26.76)	2,479,250 (73.24)	3,385,170

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

Table 2-7. Time dedicated in professional development regarding students with LEP (question 49b)

Area	≤8 h *n* (%)	9–16 h *n* (%)	17–32 h *n* (%)	≥33 h *n* (%)	Total
Mathematics	51,580 (73.72)	11,080 (15.83)	3640 (5.20)	3680 (5.25)	69,970
Science	38,210 (72.08)	8760 (16.53)	3090 (5.83)	2950 (5.57)	53,010
Technology	6560 (68.30)	1410 (14.70)	1190 (12.43)	440 (4.57)	9600
Total STM	96,340 (72.67)	21,250 (16.03)	7920 (5.97)	7070 (5.33)	132,570
All others	494,260 (63.91)	141,320 (18.27)	82,070 (10.61)	55,710 (7.20)	773,350
Total	590,600 (65.19)	162,570 (17.94)	89,980 (9.93)	62,770 (6.93)	905,920

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

Table 2-8. Perceived utility of professional development regarding students with LEP (question 49c)

Area	Not useful *n* (%)	Somewhat useful *n* (%)	Useful *n* (%)	Very useful *n* (%)	Total
Mathematics	6730 (9.61)	30,860 (44.10)	23,740 (33.93)	8640 (12.35)	69,970
Science	3330 (6.28)	22,460 (42.37)	19,820 (37.38)	7410 (13.97)	53,010
Technology	910 (9.45)	3330 (34.72)	3190 (33.26)	2170 (22.56)	9600
Total STM	10,960 (8.27)	56,650 (42.73)	46,750 (35.26)	18,210 (13.74)	132,570
All others	40,360 (5.22)	236,630 (30.60)	336,870 (43.56)	159,490 (20.62)	773,350
Total	51,320 (5.67)	293,280 (32.37)	383,620 (42.35)	177,700 (19.62)	905,920

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

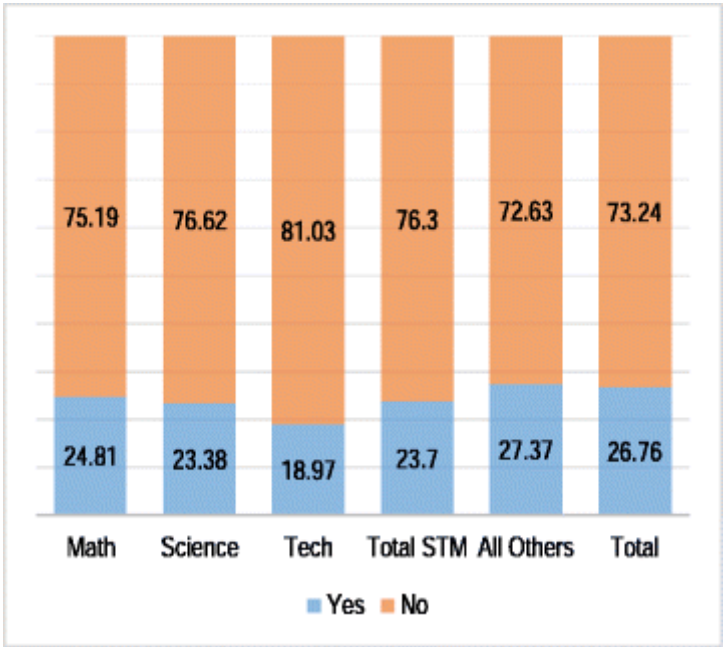

Figure 2-6. Participation in professional development regarding students with LEP (question 49a)

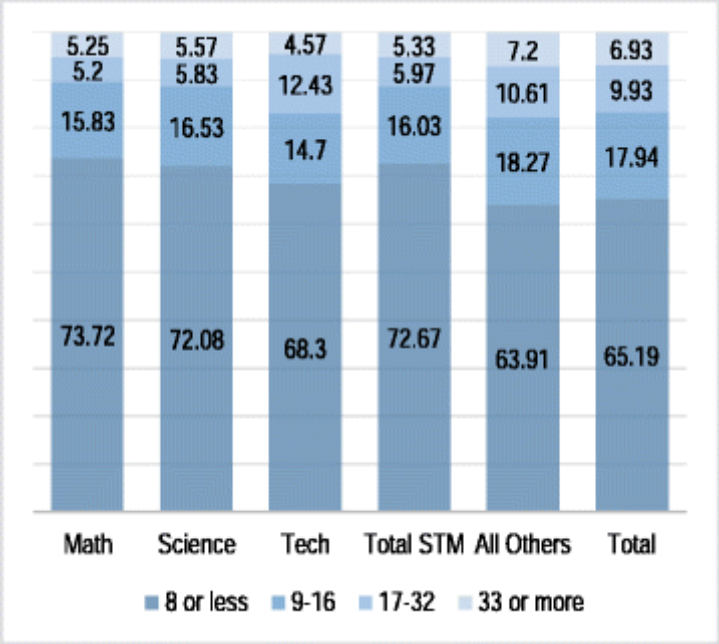

Figure 2-7. Time dedicated in professional development regarding students with LEP (question 49b)

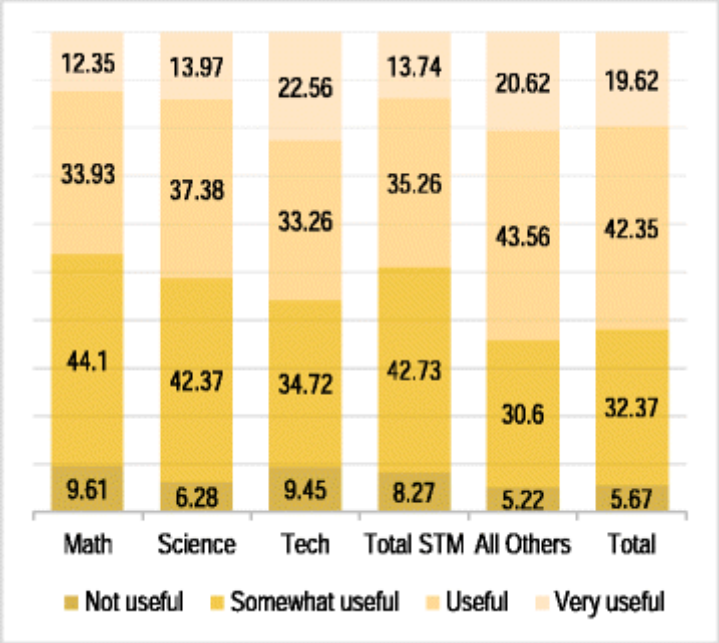

Figure 2-8. Perceived utility of professional development regarding students with LEP (question 49c)

Conclusions

Growing job opportunities are offered in STEM fields (Richards & Terkanian, 2013) to maintain pace with our STEM-infused societal demands. Knowledge in STEM fields enables citizens to make thoughtful decisions about important scientific and engineering programs

(Ravitch, 2013). Classrooms in the USA are becoming increasingly inclusive (Ernst et al., 2014). It is important for children of new immigrants to actively participate in STEM opportunities that have prospective impacts on the future development of their country. However, student disabilities or non-proficiency in language obstructs them from STEM learning and career success. Underrepresented and underserved students should be given equal educational opportunity as their peers (Spring, 2011). Students with categorical disabilities and LEP may need specialized programming, and their teachers should be prepared to help these students have an equal chance of succeeding in STEM education classrooms and future careers.

Kennedy (1999) pointed out the importance of pedagogical content knowledge for science teaching. The significance of developing knowledge and strategies beyond subject content should be valued by STM teachers. Professional development that is closely aligned with practice helps teachers address student learning objectives and misconceptions (Penuel et al., 2007). For teachers to make substantial changes in their classroom practices, a considerable amount of professional development is needed (Wei et al., 2009). However, the results from this study indicate that STM teachers tend to engage in fewer professional development opportunities regarding students with categorical disabilities, as well as LEP, than the remainder of the teaching population. Even among the STM teachers indicating engagement in the categorical professional development opportunities, fewer hours of participation were reported.

Technology education teachers are more closely aligned with the broader teacher population than science educators and mathematics educators, although technology educators are the least likely to actually participate in LEP professional development. The naturally integrative nature of technology education paired with its absence of required accountability testing may have resulted in its close alignment with the broader educational community in that it possesses

some notable intersections and similar professional requirements and needs. Through general observation, there are a multitude of professional development opportunities for STM educators. However, many of these tend to be initiative-based or content-specific. This current trend in professional development offerings could be a contributing factor in STM educators not being active participants in practice-centric opportunities. Wei et al. (2010) reported that national investments in teacher learning regarding teaching LEP and students with disabilities appear to trend toward focusing on ineffective short-term workshops. Teachers, especially science and mathematics educators, should be encouraged to participate in and be offered more opportunities of quality practice-oriented professional development. A limitation of the data collected is the inability to elaborate on the types of activities that teachers attended. Teachers evaluated the utility of all the professional development activities they have participated in targeting students with disabilities and LEP during the school year.

Overall, STM teachers' perceived utility of the provided professional development experience was lower than that of the remainder of the teaching population. Most notably, science educators tend to find the professional development less useful when it is related to teaching students with categorical disabilities, while mathematics educators find it less useful in teaching students with LEP.

These descriptive results may raise further interest among STEM educators and researchers on the granular level of professional development experiences for STEM teachers. Given the intent of the current study, descriptive statistical procedures provided a general overview and useful estimated information on the target population. These findings stand to be further advanced through a separate qualitative study to explore the issues that STM teachers have found in their professional development experiences related to students with disabilities and

those with LEP. However, the current dataset does not permit an analysis of the relationships between teachers' professional development and their actual teaching outcome. Another limitation of the study is that school level (elementary, middle, or high school) is not consistent across the USA. Therefore, grade level is not a viable separation within the closed dataset. Even so, SASS TQ offers potential for future research investigating connections and correlations across results that could provide more information on the topic and suggests areas of interest to enlighten future studies.

Alternative formats of professional development may be needed to improve teacher perceived utility. Aligned educational school goals would also help teachers build coherence between these professional development opportunities and their own teaching objectives (Lumpe et al., 2000). Furthermore, the concepts of universal design, as well as practical techniques such as the use of internet resources, multimedia demonstration methods, and teaching applications should be introduced to teachers, in accord with equipment and accessible resources. It is necessary for contemporary STEM education teachers to raise the awareness of the importance of pedagogical content knowledge and knowledge about learners. Sufficient and useful professional development programs, addressing the special needs of students with LEP and categorical disabilities, are necessary in order to adequately understand student needs and adapt classroom practices for diverse learner groups within the new integrated STEM learning context.

Declarations

Open Access

original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

This article was a collaborative work of three authors. The primary author SL proposed the research idea, designed the study, wrote the bulk of the manuscript, prepared the charts and tables, and participated in all stages of development as well as being the primary person to respond to reviewer questions and complete manuscript revisions. JVE contributed to the conclusions, the literature review and development, and framing the research questions, editing, and answering reviewer questions. TOW contributed to IES data approval process, data acquisition, data analysis, methods and results, and editing and answering reviewer questions. The workload allocation was about 60, 20, and 20 %, respectively. All authors read and approved the final manuscript.

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Chapter 3. Manuscript Two

Inclusive STEM education: Teacher satisfaction and retention

Songze Li, Jeremy V. Ernst, and Thomas O. Williams

Abstract

The issue regarding teacher satisfaction and retention within K-12 science, technology, engineering, and mathematics (STEM) education is an alarming concern. STEM teachers are challenged by the considerable numbers of students with categorical disabilities and Limited English Proficiency (LEP) enrolled in inclusive classrooms. The effective professional development could help maintain teacher satisfaction and retain them in the teaching profession. However, it remains unclear whether the service load and professional development regarding the concerned groups of students are associated with teacher satisfaction and retention. This study adopted a secondary analysis on the national data retrieved from the 2011-12 School and Staffing Survey Teacher Questionnaire (SASS TQ). STEM teacher satisfaction and intent to remain in teaching were explored, and the potential links to teacher service load and professional development specific to students with disabilities and LEP were examined. Results from Wald tests indicated that K-12 STEM educators were less likely to feel satisfied or intent to remain than all other educators. Logistic regressions suggested that teacher satisfaction and intent to remain associated with the service load of students with LEP and professional development concerning students with disabilities in STEM education, especially for science educators.

Keywords
STEM education, School and Staffing Survey Teacher Questionnaire, Students with disabilities, Limited English proficiency, Teacher professional development, Teacher satisfaction, Teacher retention

Inclusive STEM Education

Teacher Satisfaction and Retention

Introduction

Teacher attrition is a primary factor in the teacher shortage currently being experienced within the United States (Brown &Wynn, 2007). An estimated 400,000 to 500,000 teacher vacancies need to be filled largely due to teacher attrition (Gruber, Willey, Broughman, Strizek, & Burian-Fitzgerald, 2002; U.S. Department of Education, 2014). Considerable teacher attrition results in notable costs to schools, districts, and states in terms of recruiting, hiring, and training new faculty. Teachers leaving causes severe issues in teacher shortage and teaching quality in the United States public school systems, and thereby impacts student achievement (Hancock, 2009; Grissmer & Kirby, 1997; Podgursky, Monroe, & Wastson, 2004; Watlington, Shockley, Guglielmino, & Felsher, 2010; Voke, 2002).

Research has suggested that teacher intent to leave the field is an accurate predictor of teachers actually leaving the classroom (Gersten, Keating, Yovanoff, & Harniss, 2001). One major reason for teachers leaving the profession is low satisfaction with their assigned role. Teacher dissatisfaction about teaching students may drive teachers to leave their schools or even leave the profession (Metz, 1993). Job dissatisfaction has been identified as significantly associated with teachers leaving their profession within the first three years (Johnson & Birkeland, 2003).

Teachers serve diverse student populations in the United States. Considerable numbers of students with disabilities and students who have linguistic barriers are enrolled in regular classrooms (Burgstahler, 2011). Students with categorical disabilities are classified in one or more of the 13 categories identified by the Individuals with Disabilities Education Act (IDEA)

for children and youth ages three through twenty-one: 1) autism; 2) deaf-blindness; 3) deafness; 4) emotional disturbance; 5) hearing impairment; 6) intellectual disability; 7) multiple disabilities; 8) orthopedic impairment; 9) other health impairment; 10) specific learning disability; 11) speech or language impairment; 12) traumatic brain injury; and 13) visual impairment (including blindness) (National Dissemination Center for Children with Disabilities, 2012). Students who speak a language other than English at home and perform at a level below his or her native English speaking peers are considered as having Limited English Proficiency (LEP). These students may be also referred to as "English language learners (ELLs)", "Linguistic/language minorities (LM)", and "emergent bilingual (EB)" by educators (García 2009; Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997). These two groups of students tend to score lower than peers in Science, Technology, Engineering, and Mathematics (STEM) education (Thurlow, Bremer, & Albus, 2011; Newman et al. 2011). The difficulties that students with disabilities and LEP usually have in learning may impact teachers' perceived effectiveness and job satisfaction. In addition, students with disabilities and LEP tend to have systemic barriers to engage in course activities (Newman et al., 2011). Student disengagement has been shown to diminish teacher satisfaction also (Johnson, Berg, & Donaldson, 2005; Metz, 1993).

Extensive study on student characteristics has revealed that student achievement levels, and proportions of students of color and poverty had predictive relationships to teacher satisfaction and retention (Johnson, Berg, & Donaldson, 2005; Heyns, 1988; Theobald, 1990; Shen, 1997; Boyd, Lankford, Loeb, & Wyckoff, 2005; Carroll, Reichardt, Guarino, & Mejia, 2000; Hanushek, Kain, & Rivkin, 2004; Scafidi, Sjoquist, & Stinebrickner, 2005). Similarly, K-12 STEM teachers who have high service loads of students with disabilities and LEP may also be at high risk to leave the field. However, there is limited research to evidence such an effect.

Johnson, Berg, and Donaldson (2005) concluded from several studies that a prior understanding of students' cultural backgrounds, and training and preparation targeting certain subgroups of students may increase their perceived competence in teaching these students, thereby influencing teacher retention. Professional development can influence teacher intent to remain for those who work with students with special needs. Path analysis showed that professional development opportunities had positive effects on teacher commitment, thus influencing teacher intent to stay in special education (Gersten, Keating, Yovanoff, & Harniss, 2001). A lower turnover rate is identified for teachers who participated in a Professional Development School as opposed to those who did not (Latham & Vogt, 2007). These schools provided professional development opportunities to in-service teachers and the training had a focus on supporting student learning (National Council for the Accreditation of Teacher Education, 2001). Teachers who feel that they are prepared tend to remain in the field (Chapman & Green, 1986; Darling-Hammond & Youngs, 2002). Professional development opportunities which specifically address the classroom circumstance that a teacher faces would be more helpful to prepare teachers in his or her daily teaching tasks. Professional development addressing accommodations of learners with special needs can positively influence teachers' attitude and perceived competence to serve diverse student groups (Bos, Nahmias, & Urban, 1997). Participation in professional development introducing new pedagogies that help teachers construct creative learning activities that adapt to their classroom and engage students might also improve teacher satisfaction (Stempien & Loeb, 2002). Professional development centered on students with disabilities and LEP may further equip teachers with knowledge of teaching the specified groups of students, increase teacher self-confidence in teaching these students, improve

teaching outcomes, and therefore, lessen teacher attrition and promote better educational service in an inclusive context.

Research has also shown that mathematics, science, and special education were fields with the highest teacher turnover (Ingersoll, 2001). Compared to the remainder of the teaching population, STEM had higher service load of students with disabilities and LEP, however, STEM teacher participation and perceived utility regarding these specified students tend to be lower than all other teachers (Li, Ernst, & Williams, 2015). However, there is rarely solid analysis exploring the links between teacher service load and professional development participation for the specified groups of students regarding teacher satisfaction and retention in STEM education.

Research Questions

This study explored the existence of relationships between K-12 STEM teacher service load and participation in professional development regarding students with disabilities and LEP and teacher satisfaction and their intent to remain in the teaching profession within the United States public schools. The investigation was guided by the following research questions:

(1) To what extent does teacher service load of students with disabilities predict teacher satisfaction and intent to remain in teaching in K-12 STEM education?

(2) To what extent does teacher service load of students with LEP predict teacher satisfaction and intent to remain in teaching in K-12 STEM education?

(3) To what extent does participation in professional development centered on students with disabilities predict teacher satisfaction and intent to remain in teaching in K-12 STEM education?

(4) To what extent does participation in professional development centered on students with LEP predict teacher satisfaction and intent to remain in teaching in K-12 STEM education?

Instrumentation

This study employed the 2011-12 School and Staffing Survey Teacher Questionnaire (SASS TQ) dataset, which is the most recent accessible data of the SASS TQ. The purpose, procedure, and properties of the instrument are described as follows:

> The SASS is conducted by the 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. SASS is a large-scale sample survey of K–12 school districts, schools, teachers, library media centers, and administrators in the United States.
>
> SASS was designed to produce national, regional, and state estimates for public elementary and secondary schools and related components (e.g., schools, teachers, principals, school districts, and school library media centers); national estimates for BIE-funded and public charter schools and related components (e.g., schools, teachers, principals, and school library media centers); and national, regional, and affiliation strata estimates for the private school sector (e.g., schools, teachers, and principals). Therefore, SASS is an excellent resource for analysis and reporting on elementary and secondary educational issues. (Tourkin, et al., 2010, p. 8-9)

The 2011-12 SASS consists of five sets of questionnaires: School District Questionnaire, Principal Questionnaires, School Questionnaires, Teacher Questionnaires, and School Library

Media Center Questionnaire. Teacher Questionnaires include the Teacher Questionnaire (for public school teachers) and Private School Teacher Questionnaire. Teacher Questionnaire 2011-12 gathers information about public school teacher from the following aspects: I) General information, II) Class organization, III) Education and training, IV) Certification, V) Professional Development, VI) Working conditions, VII) School climate and teacher attitudes, VII) General employment and background information, and IX) Contact information.

A complex sample design was involved to get a national representative sample. Data were collected, cleaned, and weighted to form a data package for secondary analysis. Detailed information about the instrumentation and dataset could be found on the SASS website (https://nces.ed.gov/statprog/handbook/sass.asp).

Methods

This study involved a secondary analysis of the SASS TQ 2011-12 dataset. Initial access to this dataset was authorized to the authors' institution. Designated single-site user admittance to this dataset was provided to research team members. Due to the NCES and IES requirements, all weighted *n*'s (weighted numbers of observations) have been rounded to the nearest ten people when reported. The rounding method may result in minor differences between the cumulative total and the reported total in narratives and tables.

Descriptive analysis was adopted to capture the characteristics of the variables of interest. Variables were recoded for inferential analysis. The Wald test for independence was used to compare job satisfaction and intent to remain between STEM and all other teachers. Logistic regressions were conducted to explore the relationships between the predictors and the two dependent variables. These variables are described later in this Methods section. Statistics were computed based on complex survey samples (Lee & Forthofer, 2006; Williams, 2015). R codes

used in this study were generated following Lumley's (2010) guidance regarding analysis on complex surveys (see Appendix A for R codes).

Participants

The target population studied in this research was K-12 public school STEM teachers in the United States. Survey question 16 was used to identify target participants: "This school year what is your MAIN teaching assignment at THIS school?". Based on responses, teachers were categorized into four main groups: science teachers, mathematics teachers, technology teacher, and other teachers. Science, mathematics, and technology teachers were combined to form STEM teachers. Code 197 computer science was excluded from the category of Mathematics since the scope of content is inconsistent among states. The codes, corresponding subjects, and categories are shown in Table 3-1.

Table 3-1. Teacher main teaching assignments and corresponding codes

	Category	Code	Main teaching assignment
STEM	Science	211	Biology or life sciences
		212	Chemistry
		213	Earth sciences
		217	Physics
		210	Other natural sciences
	Mathematics	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
		201	Trigonometry
	Technology	246	Construction Technology
		249	Manufacturing Technology
		250	Communication Technology
		255	General Technology Education
Others			All other subjects

Dependent Variables

The two dependent variables in this study were teacher job satisfaction and intent to remain in teaching. Teacher job satisfaction was measured by question 63q: "To what extent do you agree or disagree with each of the following statements? I am generally satisfied with being a teacher at this school". Participants responded on a four-level Likert scale: 1) Strongly agree, 2) Somewhat agree, 3) Somewhat disagree, 4) Strongly disagree.

In this study, teacher job satisfaction was recorded as a dummy variable. Participants who responded with code 1 or 2 ("strongly agree" or "somewhat agree") to question 63q were combined and recoded as 1 (satisfied); participants who responded 3 or 4 ("somewhat disagree" or "strongly disagree") were combined and recoded as 0 (unsatisfied).

The second dependent variable, teacher' intent to remain in teaching, was measured by question 66b: "How long do you plan to remain in teaching?". Participants selected one response from eight options: 1) As long as I am able; 2) Until I am eligible for retirement benefits from this job; 3) Until I am eligible for retirement benefits from a previous job; 4) Until I am eligible for Social Security benefits; 5) Until a specific life event occurs (e.g., parenthood, marriage); 6) Until a more desirable job opportunity comes along; 7) Definitely plan to leave as soon as I can; 8) Undecided at this time.

To explore the potential influence of predictors on teachers that intend to remain or leave, the extreme categories were selected to conduct extreme group comparisons. Participants who responded with code 1 ("as long as I am able") to question 66b were coded as 1 (intend to remain); participants who responded 6 or 7 ("until a more desirable job opportunity comes along" or "definitely plan to leave as soon as I can") were combined and recoded as 0 (intend to leave).

Independent Variables

The four independent variables of interest or predictors were teacher service load of students with disabilities, teacher service load of students with LEP and participation in professional development concerning students with disabilities and LEP. Teacher service load was defined as the total number of students of the specified subgroup that a teacher taught at the current school during the 2011-12 school year. The two continuous variables were measured respectively by SASS TQ question 14, "Of all the students you teach at this school, how many have an Individualized Education Program (IEP) because they have disabilities or are special education students?" and question 15, "Of all the students you teach at this school, how many are of limited-English proficiency or are English-language learners (ELLs)?".

Two "yes-or-no" type questions were adopted to measure teacher participation in the specified practice-oriented professional development. Question 48a, "In the past 12 months, have you participated in any professional development on how to teach students with disabilities?" was used for teacher participation in professional development centered on students with disabilities; and 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)?" was used concerning students with LEP.

A set of professional and social factors were selected as confounding variables based on existing literature (Weiss, 1999; Shen, 1997). The confounding variables included teacher gender, race, master's degree earned, new teacher, and school-related yearly earnings. Table 3-2 summarizes the variables used in this study. Design weight and replicate weights were assigned by the complex sample design. The 88 replicate weights were used to calculate standard errors and *p*-values.

Table 3-2. Summary of variables and recoding

Role	Variable name used in analysis	Description	Recode	SASS TQ variables used
Identifying participants	Subject	STEM teachers in public schools	See Table 1	T0090
Dependent variable	SATISFACTION	Teacher job satisfaction	1 = satisfied 0 = unsatisfied	T0451
	RETENTION	Teacher intent to remain in teaching	1 = intent to remain 0 = intent to leave	T0473
Independent variable/ predictor	SL_DIS	Service load of students with disabilities	Continuous	T0085
	SL_LEP	Service load of students with LEP	Continuous	T0086
	PD_DIS	Participation in professional development regarding students with categorical disabilities	1 = participated 0 = did not participate	T0350
	PD_LEP	Participation in professional development regarding students with LEP	1 = participated 0 = did not participate	T0353
Confounding variables	GENDER	Gender	1 = male 0 = female	T0525
	MAJORITY	Racial majority	1 = White 0 = all other racial groups	T0528 – T0532
	HIDEGR	Master's degree earned	1 = having Master's degree 0 = not having Master's degree	HIDEGR
	NEWTCH	New teacher - teacher has taught 3 or fewer years	1 = new teacher 0 = not new teacher	NEWTCH
	EARNSCH	Total school-related yearly earnings (in dollar)	Continuous	EARNSCH
Weight	TFNLWGT	Design weight or final weight		TFNLWGT
	TREPWT1–TREPWT88	Replicate weights		TREPWT1–TREPWT88

Results

Descriptive Analysis and Test of Independence

Descriptive data for independent variables are summarized in Table 3-3 and 3-4 by subject. Table 3-3 shows the central tendency and dispersion of the three continuous variables. STEM teachers had higher mean and median service load of students with disabilities (SL_DIS) than all other teachers. Teacher service load of students with LEP was lower than service load of students with disabilities on average. STEM teachers had almost equal service load of students with LEP as all other teachers did. Technology teachers had the highest service load of students with disabilities and LEP.

Table 3-3. Descriptive data for independent variables (continuous variables)

Variable		STEM	Science	Math	Tech	Others	All
	N	559,290	226,700	281,990	50,610	2,825,880	3,385,170
SL_DIS	Mean	12.10	13.41	9.84	18.87	11.25	11.39
	Std. D.	14.257	14.261	10.566	25.123	17.425	16.945
	Median	9	10	7	12	5	6
	Min	0	0	0	0	0	0
	Max	231	126	100	231	483	483
SL_LEP	Mean	6.58	7.1	5.98	7.6	7.28	7.17
	Std. D.	14.956	15.892	12.899	20.236	25.231	23.843
	Median	1	1	1	1	1	1
	Min	0	0	0	0	0	0
	Max	200	185	170	200	700	700
EARNSCH	Mean	54,834.82	54,819.06	54,444.16	57,082.29	54,131.12	54,247.38
	Std. D.	17,713.110	17,793.635	17,075.533	20,461.025	17,237.995	17,319.361
	Median	51,500	51,800	51,000	53,400	51,090	51,200
	Min	1,500	1,500	2,500	6,000	520	520
	Max	159,700	141,800	144,000	159,700	150,175	159,700

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

Table 3-4 shows the frequencies and percentages for the six dummy variables. The rates of participation in professional development concerning students with disabilities and LEP for STEM teachers were lower than that for all other teachers. The rates of participation in professional development concerning students with LEP were lower than that concerning students with disabilities for all groups of teachers.

Table 3-4. Contingency table for independent variables (dummy variables)

Variable	Category	STEM	Science	Math	Tech	Others	All
PD_DIS	Did not participated = 0	388,580	158,070	196,970	33,540	1,729,930	2,118,510
		69.5%	69.7%	69.9%	66.3%	61.2%	62.6%
	Participated = 1	170,710	68,630	85,020	17,070	1,095,950	1,266,660
		30.5%	30.3%	30.1%	33.7%	38.8%	37.4%
PD_LEP	Did not participated = 0	426,720	173,690	212,020	41,010	2,052,530	2,479,250
		76.3%	76.6%	75.2%	81.0%	72.6%	73.2%
	Participated = 1	132,570	53,010	69,970	9,600	773,350	905,920
		23.7%	23.4%	24.8%	19.0%	27.4%	26.8%
GENDER	Female = 0	336,570	140,170	183,940	12,460	2,246,980	2,583,550
		60.2%	61.8%	65.2%	24.6%	79.5%	76.3%
	Male = 1	222,720	86,520	98,050	38,150	578,900	801,630
		39.8%	38.2%	34.8%	75.4%	20.5%	23.7%
MAJORITY	Minority = 0	64,690	24,930	35,680	4,080	273,640	338,330
		11.6%	11.0%	12.7%	8.1%	9.7%	10.0%
	White = 1	494,600	201,770	246,310	46,520	2,552,240	3,046,840
		88.4%	89.0%	87.3%	91.9%	90.3%	90.0%
HIDEGR	Not Master's degree = 0	242,640	93,590	121,670	27,380	1,235,320	1,477,960
		43.4%	41.3%	43.1%	54.1%	43.7%	43.7%
	Having Master's degree = 1	316,650	133,110	160,320	23,230	1,590,560	1,907,210
		56.6%	58.7%	56.9%	45.9%	56.3%	56.3%
NEWTCH	Not a new teacher = 0	484,080	199,220	240,610	44,260	2,519,730	3,003,810
		86.6%	87.9%	85.3%	87.5%	89.2%	88.7%
	New teacher = 1	75,210	27,480	41,380	6,350	306,150	381,360
		13.4%	12.1%	14.7%	12.5%	10.8%	11.3%
Total		559,290	226,700	281,990	50,610	2,825,880	3,385,170
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

The counts and percentages for teacher satisfaction and intent to remain are also tabulated (see Table 3-5) and illustrated (see Figure 3-1 and 3-2). STEM teachers as a whole and the three subgroups demonstrated a rate of being satisfied from 88.3 to 88.9 percent, while 90.5 percent of all other teachers were satisfied about their job. Technology was the field with the lowest satisfaction. About 88 percent of all other teachers intended to remain while only 83 percent of STEM teachers hold the same intent. Technology teachers had the highest rate of intent to remain and science teachers had the lowest rate among all STEM teachers. Descriptive data showed relatively low proportions of being satisfied and intent to remain for STEM teachers in comparison to all other teachers.

Table 3-5. Contingency table for satisfaction and intent to remain by subject

Variable	Category	STEM	Science	Math	Tech	Others	All
Satisfaction	Unsatisfied	63,000	25,740	31,360	5,900	269,490	332,480
		11.3%	11.4%	11.1%	11.7%	9.5%	9.8%
	Satisfied	496,290	200,950	250,630	44,710	2,556,390	3,052,690
		88.7%	88.6%	88.9%	88.3%	90.5%	90.2%
	Total	559,290	226,700	281,990	50,610	2,825,880	3,385,170
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Intent to remain	Intent to leave	48,730	23,100	22,240	3,390	178,060	226,780
		16.8%	19.9%	15.2%	12.3%	11.8%	12.6%
	Intent to remain	241,540	93,140	124,250	24,160	1,336,450	1,577,990
		83.2%	80.1%	84.8%	87.7%	88.2%	87.4%
	Total	290,270	116,240	146,490	27,550	1,514,500	1,804,770
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note. Weighed sample values are rounded to the nearest 10 per NCES protocol

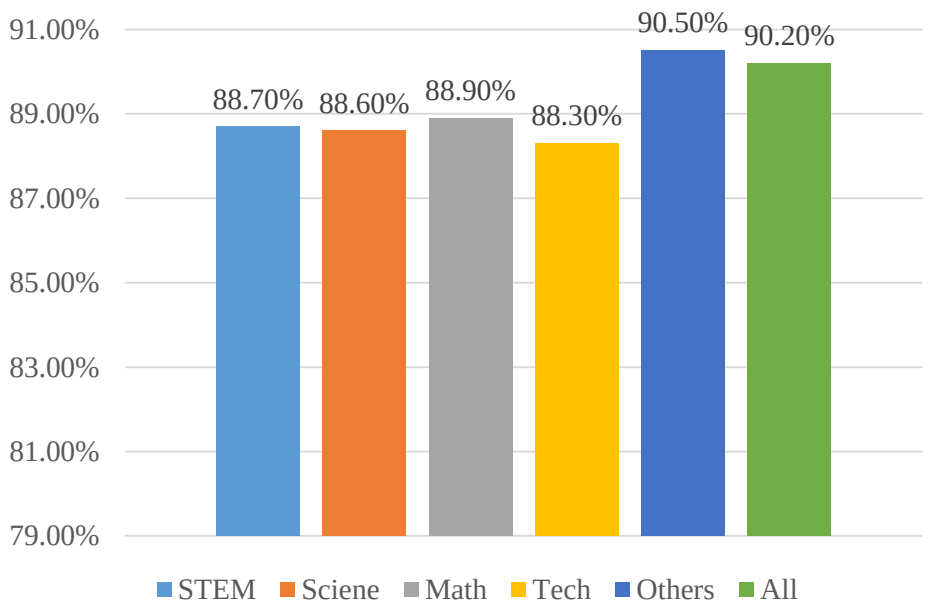

Figure 3-1. Proportion of teacher being satisfied

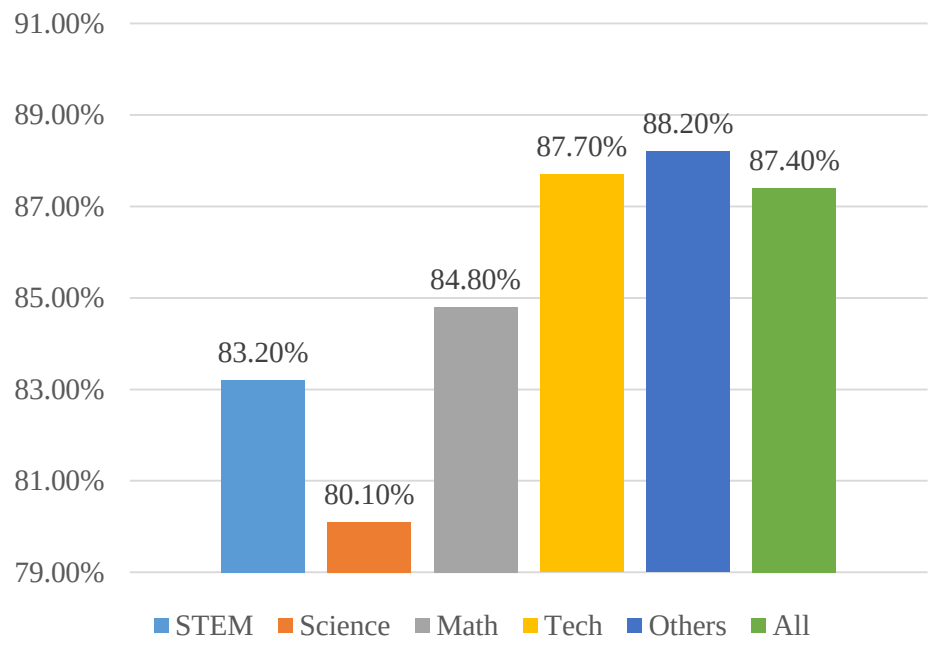

Figure 3-2. Proportion of teacher intent to remain

The Adjusted Wald test of independence, based on the differences between the observed cells counts and those expected under independence, was adopted to test whether the satisfaction and intent to remain of STEM teachers differed from all other teachers (Koch, D. Freeman, & J. Freeman, 1975; Thomas & Rao, 1990). The Wald statistic was converted to an *F* statistic as to determine the *p* value for complex survey data analysis (Lee & Forthofer, 2006; Williams, 2015; Lumley, 2010). Results from the Wald tests showed that STEM teachers were less satisfied than all other teachers, and had lower intent to remain in teaching (see Table 3-6).

Table 3-6. Tests of independence for satisfaction and intent to remain

Category	STEM (*n* (%))	Others (*n* (%))	*ndf*	*ddf*	*F*-statistics	*p*-value
Unsatisfied	63,000 (11.3)	269,490 (9.5)	1	87	4.040	.048
Satisfied	496,290 (88.7)	2,556,390 (90.5)				
Intent to leave	48,730 (16.8)	178,060 (11.8)	1	87	24.703	<.001
Intent to remain	241,540 (83.2)	1,336,450 (88.2)				

Logistic Regression

Satisfaction. Logistic regression was conducted to test the research hypotheses regarding the relationship between the likelihood that a teacher is generally satisfied and his or her service

load and participation of professional development concerning students with disabilities and LEP for the five teacher groups. The model contained four predictors of interest (service load of students with disabilities, service load of students with LEP, participation in professional developments regarding students with disabilities, participation in professional development regarding students with LEP) and five confounding variables (gender, racial majority, having master's degree, new teacher, total school-related yearly earnings) that were suggested in previous literature. Service load of students with disabilities, service load of students with LEP, and total school-related early earnings were continuous variables. The other six variables were categorical or ordinal, and have been recoded as dummy variables to facilitate analysis and respond to the NCES statistical requirements on data stability.

The logistic regression model for K-12 STEM teachers is presented as Model 1 (see Appendix A for R codes generated for these logistic models, see Appendix B for correlation tables, and see Appendix C for R outputs for the models). The *t* statistics instead of conventional *z* statistics were computed for analyzing complex survey data (Lee & Forthofer, 2006; Williams, 2015; Lumley, 2010). Interpretation of the logistic regression in this study was guided by Peng, Lee, & Ingersoll's (2002) and Buis's (2015) papers. Service load of students with LEP was the only significant variable for STEM teacher satisfaction (*p*-value = .025, odds ratio ($e^{-.01032}$)= .990). The result indicated that service load of students with LEP has significant effect on the likelihood of a teacher being satisfied at a .05 significance level, after controlling for other variables in the model. The higher the service load of students with LEP, the less likely a STEM teacher would be satisfied. Service load of students with LEP also negatively associated with teacher satisfaction for science teachers (*p*-value = .011, odds ratio = .985, see Model 2 in Appendix C) and other teachers (*p*-value = .018, odds ratio = .995, see Model 5 in Appendix C).

There was no significant effect detected for satisfaction of mathematics teachers (see Model 3 in Appendix C) and technology teachers (see Model 4 in Appendix C) in the current study.

Results showed that participation in professional development regarding students with disabilities positively influenced the likelihood of being satisified for all other teachers (*p*-value = .013, odds ratio = 1.302, see Model 5 in Appendix C), but the similar effect was not found for STEM teachers. School-related earnings positively associtied with all other teacher satisfaction with a *p*-value of .005 and an odds ratio slightly greater than one.

Intent to remain. The logistic regression model of teacher intent to remain in teaching was paralleled with that of teacher satisfaction, including four predictors and five confounding variables. The model was analyzed for five subpopulatioins: K-12 STEM teachers (see Model 6 in Appendix C), science teachers (see Model 7 in Appendix C), mathematics teachers (see Model 8 in Appendix C), technology teachers (see Model 9 in Appendix C), and all other teachers (see Model 10 in Appendix C).

Teacher service load of students with either disabilities or LEP was not found to have a significant effect on intent to remain for any of the five subpopulations examined in this study. Participation of professional development regarding students with LEP was not found to be signifiant in any model.

Teacher participation of professional development regarding students with disabilities had a positive effect on the likelihood of intent to remain for STEM teachers, science teachers, and all other teachers, after controlling for other variables in the model. The odds of intent to remain was about 1.5 times higher for a STEM teacher who participated in such professional development than who did not (*p*-value = .011, odds ratio = 1.519, see Model 6 in Appendix C), and for all other teachers the odds ratio of intent to remain was 1.288 (*p*-value = .032, see Model

10 in Appendix C). Specificlly, the odds of intent to remain for a science teacher who participated was nearly two times higher than who did not (*p*-value = .028, odds ratio = 1.781, see Model 7 in Appendix C).

In addition, school-related earnings was found to have positively impact on the likelihood of teacher intent to remain for all subpopulations except for technology teachers. Gender and being a new teacher (who had three years or less experience) showed significant effects for all other teachers. The odds of intent to remain for a new teacher was 1.5 times higher than that for an experienced teacher (*p*-value = .022, odds ratio = 1.517, see Model 10 in Appendix C). Females were more likely to report intent to remain in teaching. Table 3-7 summarizes the significant findings of the ten logistic regression models. The statistics regarding model fit for these models are shown in Table 3-8. Pseudo R-squares indicated that the models accounted for about 1 to 6 percent of the variance. The *p*-values suggested that models for STEM, mathematics, and all other teacher satisfaction, and models for STEM, science, and all other teacher intent to remain had significant improvement over the null models.

Table 3-7. Summary of significant results of logistic regressions

Dependent variable	Independent variable	STEM	Science	Math	Tech	Others
Satisfaction (Odds ratio (*p*-value))	Service load of students with LEP	.990 (.025)	.985 (.011)			.995 (.018)
	Professional development regarding students with disabilities					1.302 (.013)
	Total school-related yearly earnings					>1.000 (.005)
Intent to remain (Odds ratio (*p*-value))	Professional development regarding students with disabilities	1.519 (.011)	1.781 (.028)			1.288 (.032)
	Gender (male = 1, female = 0)					.760 (.047)
	New teacher					1.517 (.022)
	Total school-related yearly earnings (in dollars)	>1.000 (<.001)	>1.000 (.029)	>1.000 (.001)		>1.000 (<.001)

Table 3-8. Summary of model fit of logistic regressions

Dependent variable	Test statistics	STEM	Science	Math	Tech	Others
Satisfaction	McFadden Pseudo R^2	.015	.023	.017	.028	.009
	Adjusted Wald Test ($F_{9,80}$ (p-value))	2.623 (.010)	1.374 (.214)	2.067 (.042)	.555 (.830)	4.153 (<.001)
Intent to remain	McFadden Pseudo R^2	.026	.040	.024	.056	.018
	Adjusted Wald Test ($F_{9,80}$ (p-value))	3.015 (.004)	2.093 (.040)	1.652 (.115)	.618 (.778)	7.359 (<.001)

Conclusion and Discussion

K-12 STEM teachers were generally less satisfied than the remainder of the teaching population, and they were more likely to leave the teaching profession. This conclusion confirms many previous research findings (Murnane, Singer, Willett, Kemple, & Olsen, 1991; Grissmer & Kirby, 1987), however, there are some contradictions in literature (Bobbitt, Faupel, & Burns, 1991). As explained by Shen (1997), the inconsistent findings regarding STEM teacher retention might be due to the timeframe and geographic representation, since the population and policies change over time and vary by location. K-12 STEM teachers play a critical role in encouraging and preparing K-12 students to pursue STEM majors and careers. The potential factors and underlying mechanism regarding the influence on STEM teacher satisfaction and retention deserve constant exploration.

Service load of students with LEP tends to incrementally decrease the likelihood of being satisfied with a teaching job in STEM education, especially for science teachers. Teacher's sense of students' success is important to teacher satisfaction (Lortie, 1975). Successfully teaching subject content to build higher student achievement on examinations increases teacher satisfaction (Sikes, Measor, & Woods, 1985). Linguistic and cultural barriers impede student learning and prohibit demonstration of academic knowledge and abilities, therefore, decreasing

teacher satisfaction. Moreover, many states do not have assessment accommodations specifically addressing the linguistic and cultural backgrounds of students with LEP, and only a few states have developed alternative tests specifically for students with LEP (Rivera & Collum, 2006; Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997; Rivera, Stansfield, Scialdone, & Sharkey, 2000). Existing accountability frameworks and assessment formats have a tendency to reduce actual test achievement of students with LEP (Crawford, 2004). Students with LEP might have not yet become academically literate in English before they were required to take the same tests as their native peers (Forum on Educational Accountability, 2007). National and state policies on accountability increased the test pressure and impose teacher decisions in practice (Palmer & Lynch, 2008; Palmer & Rangel, 2011). Insufficient accommodations and pressure on high-stakes assessments might hinder students with LEP from academic success, and impact teachers' confidence, sense of achievement, and autonomy, thus diminishing job satisfaction.

This study also showed that the effect of service load of students with LEP on teacher satisfaction varied among STEM disciplines. The concepts and applications in mathematics courses rely considerably on mathematical symbols and formulas. The mathematical language and logic is not divergent for native speakers or students with LEP. Technology education generally offers more demonstration and hands-on activities to students and allows student learning outcomes to be evaluated based on representations beyond speaking and writing. The alternative, non-verbal, paths of communication between teachers and students might help students with LEP keep engaged and learn, therefore alleviating the impact on teacher's self-confidence and satisfaction in teaching. Compared to mathematics and technology education, science classes contain more vocabulary and instruction which require understanding and expression of the English language. The higher linguistic requirements in science education may

explain that the negative effect of service load of students with LEP on teacher satisfaction were only found for the science teaching population among STEM subjects. In addition, compared to 34 states which designated some level of test accommodations for students with LEP for mathematics assessments, only 22 states did so for science subjects (Rivera & Collum, 2006). The inconsistent accommodations among subjects might also bias teachers' perceptions about student learning outcomes, thus influencing teachers', especially science teachers', job satisfaction.

Many students with LEP are assessed inappropriately and the current accountability system for students with LEP is misguided through federal laws and policies (Crawford, 2004). Valid assessments and appropriate accommodations for students with LEP should be designed to fully consider their linguistic and cultural needs. These accommodations should be designated in instruction, classroom evaluation, and also in high-stakes testing. Some may argue that providing accommodations to these students would add extra work for teachers, also influencing teacher satisfaction. However, the influential path from service load of students with LEP to teacher satisfaction needs further study with full consideration of teachers, students, state policies, and other factors. Interactions among factors should be examined in future study.

Participating in professional development regarding students with disabilities increased the likelihood of being satisfied for all other teachers but not for STEM teachers. One explanation could be the current professional development offerings were not effective in helping STEM teachers feel well prepared and confident to teach students with disabilities. Previous research showed that the overall perceived utility was much lower for STEM teachers than for all other teachers regarding their experience of professional development on students with disabilities (Li, Ernst, & Williams, 2015). Meaningful training programs, organized to assist

teachers in building upon abilities to address students with special needs, were not delivered to most STEM teachers.

Although it did not promote STEM teacher satisfaction, professional development on students with disabilities increased the likelihood of STEM teacher intent to remain. The measured effect was stronger for science teachers than for mathematics, technology, or all other teachers. While science teachers had the lowest intention to remain, findings suggest that science teacher engagement in professional development activity associated with teaching students with disabilities was an indicator of retention. However, the current study did not reveal the mechanism of how the current professional development programs differ in each discipline. Future study could focus on the content, format, and effectiveness of the professional development that supports teaching students with disabilities and LEP, in order to provide insights about best practices that benefit teacher retention.

In contrast to professional development on students with disabilities, professional development on students with LEP did not show a positive effect on teacher satisfaction or intent to remain based on the current analysis. This might be also due to the usefulness of these professional development offerings. National data showed that fewer STEM teachers reported their experience of professional development concerning students with LEP were useful or very useful compared to professional development concerning students with disabilities (Li, Ernst, & Williams, 2015). Future research is suggested to explore the influence of these professional development offerings on actual teaching outcomes, as well as its effect on teacher satisfaction and retention and its interactions with service load of students with disabilities and LEP.

Evidences from this study specifically suggest that the current STEM teachers had elevated service load of students with special needs in regard to other teacher subgroups, and

such service load may impact teacher satisfaction when they were not well informed and prepared. The exposure and quality of professional development experiences pertaining to students with disabilities and LEP were insufficient with respect to the considerable service load of specified students that the STEM teachers have.

More efforts are needed to design and offer effective professional development activities for STEM teachers in order to address their growing demands on working with the two concerned groups of students. Providing high-quality and targeted professional development opportunities to in-service teachers might alleviate teacher attrition. Keeping STEM teachers, especially experienced teachers, in their profession would assist in maintaining expertise and matured educational knowledge in terms of organization and practice. Furthermore, such training and preparations regarding services for students with disabilities and LEP should span beyond professional development offerings into pre-service preparation opportunities and experiences, in order to raise awareness among pre-service teachers and support them in developing necessary professional skills to respond to the challenges in the inclusive education environment.

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Chapter 4. Conclusion to the Dissertation

This dissertation addresses the current issues in the United States public schools regarding STEM teacher experience and perceptions in inclusive context from a national perspective. Two stand-alone but relevant quantitative studies have been conducted to investigate teacher service load and professional development regarding students with disabilities and LEP, as well as their potential associations to teacher job satisfaction and intention to remain in teaching profession. The series of studies employed secondary analyses on the national data retrieved from NCES 2011-12 SASS TQ. The first study was centered on K-12 STEM educator participation and perceived utility of their professional development experience regarding teaching students with disabilities and LEP. Descriptive analysis was used to categorically summarize and compare teacher service load, and levels and perceived utility of participation in professional development regarding students with disabilities and LEP across science, technology, and mathematics disciplines, and also between STEM educators and all other educators. The second study examined teacher satisfaction and intent to remain in teaching. The Wald test of independence was conducted to examine teacher satisfaction and intent to remain between STEM educators and the remainder of the teaching population. Logistic regression was adopted to explore the relationships between teacher satisfaction or intent to remain and teacher service load and professional development specific to students with disabilities and LEP. The results were compared across STEM teacher subgroups. Major findings and conclusions from the two studies are summarized as follows:

K-12 STEM teachers generally had service loads of students with LEP as all other teachers did, and STEM teachers had higher service load of students with disabilities than the remainder of teaching population. STEM teachers were less likely to engage in and generally

dedicated fewer hours in the professional development regarding students with disabilities and LEP, and their perceived utility of such professional development experience was lower, compared to all other teachers. In addition, STEM teachers were less likely to feel satisfied about their teaching job and more likely to have intent to leave the profession than their peers in other subjects.

Service load of students with disabilities did not show impact on teacher satisfaction or intent to remain for any groups of teachers examined in this dissertation research. However, a positive effect of professional development regarding students with disabilities was found to associate with teacher intent to remain for both STEM teachers and all other teachers, as well as associate with job satisfaction of all other teachers. The effect of these professional development offerings may differ based on their quality, content scope, or format.

The service load of students with LEP impacted teacher satisfaction for both STEM and all other teachers. Generally speaking, the more students with LEP a teacher had, the less likely the teacher was satisfied. Analysis of subgroups within STEM subjects showed that such a negative effect was identifiable in science education but not in mathematics or technology education. The alternative non-verbal learning approaches, such as symbol-based or hands-on, might ease the linguistic difficulties in the academic communication between teachers and students, thus maintaining teacher confidence and perceived effectiveness in teaching, therefore not significantly affecting teacher satisfaction. This finding might legitimize the adoption of hands-on or non-verbal approaches in instruction and assessments to provide accommodation to students with LEP, in order to support student learning and teachers working with these student populations.

As discussed in the overall introduction, the number of students with LEP is rapidly increasing in the United States. The service load of students with LEP showed greater influence on teacher satisfaction than the service load of students with disabilities did (which showed neutral influence in this research), however, far fewer STEM teachers participated and dedicated fewer hours to professional development regarding students with LEP when compared to that of students with disabilities. Figures 4-1 and 4-2 summarize STEM teacher participation and time dedicated in these two categories of professional development. Without sufficient exposure of professional development on students with LEP, many teachers might feel unprepared when stepping in the classroom, since most teachers reported that they had students with LEP in their classes.

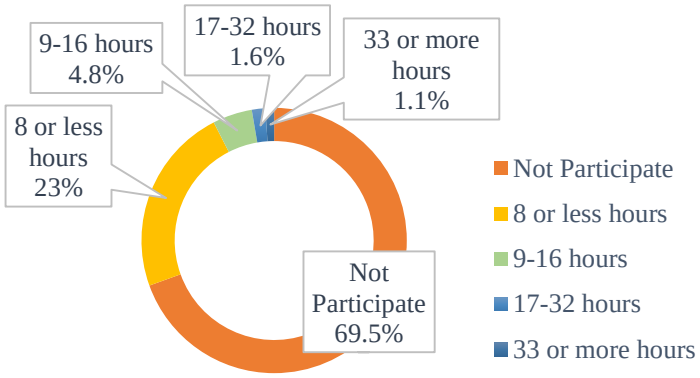

Figure 4-1. STEM teacher time dedicated in professional development regarding students with disabilities

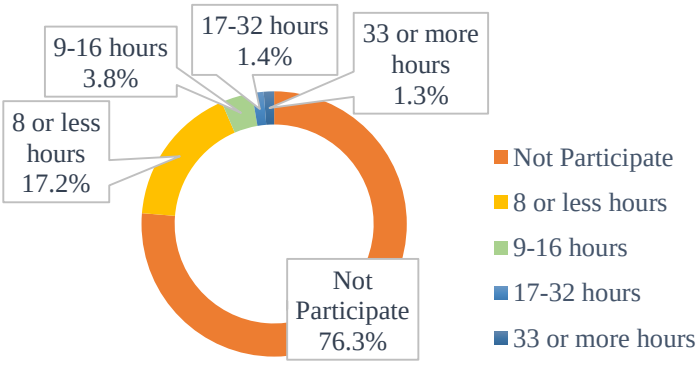

Figure 4-2. STEM teacher time dedicated in professional development regarding students with LEP

Simultaneously, fewer teachers thought that the professional development regarding students with LEP was useful than that regarding students with disabilities. Figures 4-3 and 4-4 summarize the perceived utility of professional development on students with disabilities and LEP for all STEM teachers. STEM teachers had less exposure and lower perceived utility regarding the current professional development offerings concerning students with LEP, in comparison of professional development concerning students with disabilities, although service load of students with LEP significantly impacted teacher satisfaction (while service load of students with disabilities did not). This conclusion also applied to all other teachers.

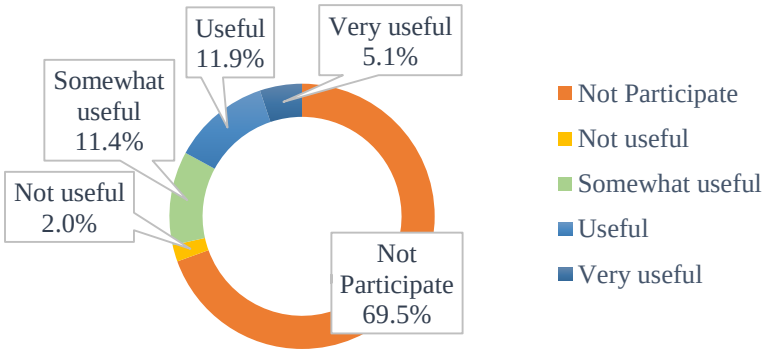

Figure 4-3. STEM teacher perceived utility of professional development regarding students with disabilities

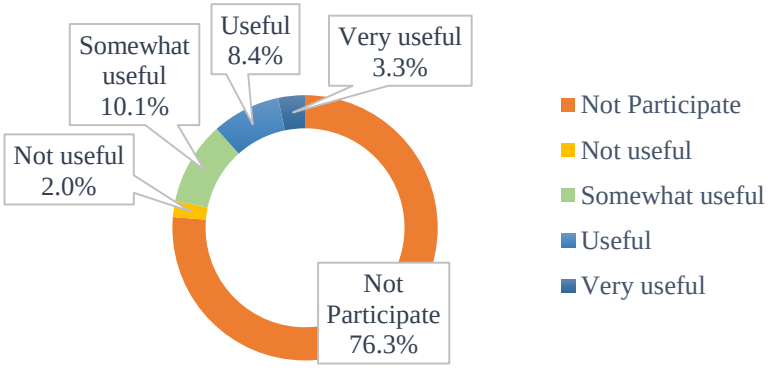

Figure 4-4. STEM teacher perceived utility of professional development regarding students with LEP

In summary, the research indicated that in terms of serve for students with disabilities and LEP, relatively low exposure and quality of professional development experience in regard to an

elevated service load of these students for K-12 STEM educators, while the service load and professional development factored for teacher satisfaction and intent to remain. Specifically, having students with LEP affected teacher satisfaction while the current professional development offerings regarding teaching this group of students were not effective concerning increase in teacher satisfaction or intent to remain. Major findings from the two studies are visualized in Figure 4-5. The research findings have partially verified the hypotheses illustrated in the conceptual framework of the dissertation (see Figure 1-3). These findings collectively suggested the necessity and imperative demands of sufficient and useful professional development offerings regarding the two concerned groups of students for retaining and supporting in-service STEM teachers in the inclusive education.

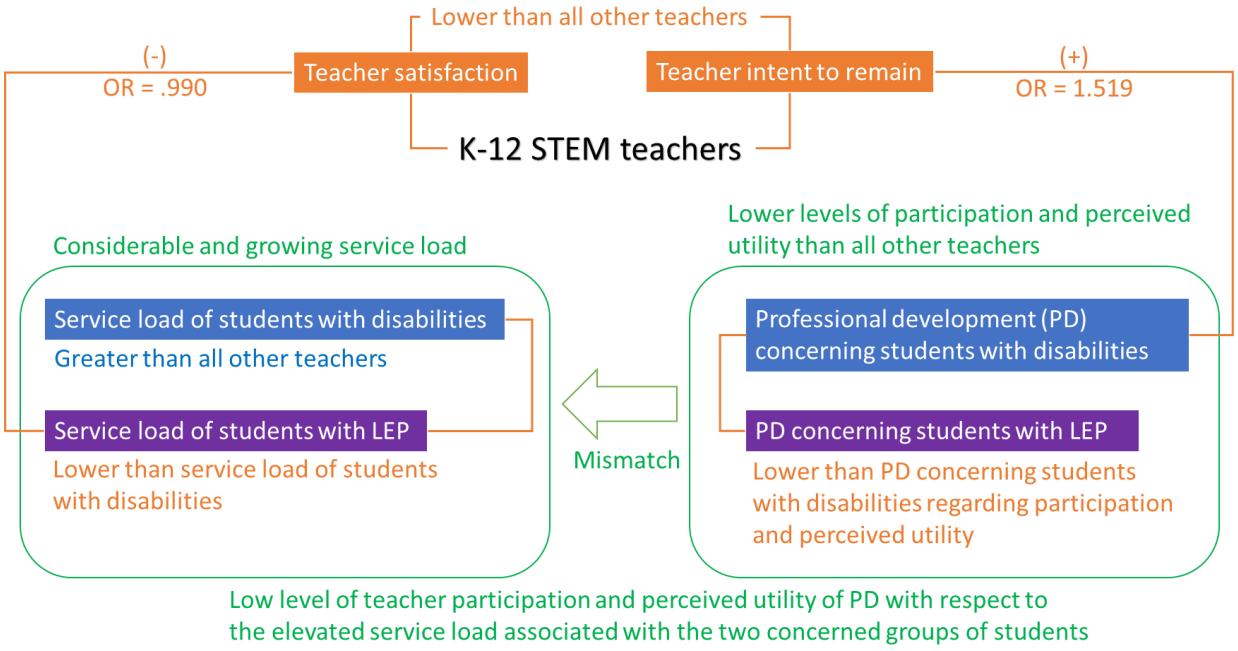

Figure 4-5. Summary of dissertation findings

Appendix A

R Codes Used for Test of Independence and Logistic Regression

R codes for Test of Independence of complex survey data

```
# Import data
library (survey)
setwd ("C:/Data")
data <- read.csv("C:/ Data/data.csv")

# Define survey design
# Column 1 to 12 are the variables used for regression, Column 13 is the final weight, Column 14 to 101 are the 88 replicate weights, and BRR = balanced repeated replication
design<- svrepdesign(variables=data [,1:12], repweights=data [,14:101], weights=data [,13], type="BRR", combined.weights=T)

# Wald tests of independence, based on the differences between the observed cells counts and those expected under independence
# STEM = 1, all others =0
svychisq( ~ STEM + SATISFACTION, design, statistic="adjWald")
svychisq( ~ STEM + RETENTION, design, statistic="adjWald")
```

R codes for Logistic Regression of complex survey data

```
# Import data
library (survey)
library(BaylorEdPsych)
setwd ("C:/Data")
data <- read.csv("C:/ Data/data.csv")

# Define survey design
# Column 1 to 12 are the variables used for regression, Column 13 is the final weight, Column 14 to 101 are the 88 replicate weights, and BRR = balanced repeated replication
design<- svrepdesign(variables=data [,1:12], repweights=data [,14:101], weights=data [,13], type="BRR", combined.weights=T)

# Define subsets
designSTEM <- subset (design, Subject==1|Subject==2|Subject==3)   # STEM teachers
designS <- subset (design,Subject==2)          # Science teachers
designT <- subset (design,Subject==3)          # Technology teachers
designM <- subset (design,Subject==1)          # Mathematics teachers
designO <- subset (design,Subject==4)          # Other teachers
```

```
# Logistic regression model for “Satisfaction”
model1 <- svyglm (SATISFACTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designSTEM, family = quasibinomial)
summary(model1)
PseudoR2(model1)

model2 <- svyglm (SATISFACTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designS, family = quasibinomial)
summary(model2)
PseudoR2(model2)

model3 <- svyglm (SATISFACTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designM, family = quasibinomial)
summary(model3)
PseudoR2(model3)

model4 <- svyglm (SATISFACTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designT, family = quasibinomial)
summary(model4)
PseudoR2(model4)

model5 <- svyglm (SATISFACTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designO, family = quasibinomial)
summary(model5)
PseudoR2(model5)

# Logistic regression model for “Intent to Remain”
Model6 <- svyglm (RETENTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designSTEM, family = quasibinomial)
summary(model6)
PseudoR2(model6)


model7 <- svyglm (RETENTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designS, family = quasibinomial)
summary(model7)
PseudoR2(model7)
```

```
model8 <- svyglm (RETENTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designM, family = quasibinomial)
summary(model8)
PseudoR2(model8)

model9 <- svyglm (RETENTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designT, family = quasibinomial)
summary(model9)
PseudoR2(model9)

model10 <- svyglm (RETENTION ~
SL_DIS+SL_LEP+PD_DIS+PD_LEP+GENDER+MAJORITY+HIDEGR+NEWTCH+EARNSCH,
design = designO, family = quasibinomial)
summary(model10)
PseudoR2(model10)
```

Appendix B

Correlation Matrixes

Matrix 1. Correlation Matrix for STEM Teachers

	SL_DIS	SL_LEP	PD_DIS	PD_LEP	GENDER	MAJORITY	HIDEGR	NEWTCH	EARNSCH	Subject	SATISFAC	RETENT
SL_DIS	1.000											
SL_LEP	0.189	1.000										
PD_DIS	0.107	0.015	1.000									
PD_LEP	0.023	0.255	0.262	1.000								
GENDER	0.029	-0.002	-0.007	-0.043	1.000							
MAJORITY	-0.015	-0.062	-0.031	-0.063	0.031	1.000						
HIDEGR	0.010	-0.005	0.004	-0.032	-0.022	-0.001	1.000					
NEWTCH	-0.002	0.021	0.010	0.039	-0.014	-0.018	-0.254	1.000				
EARNSCH	0.021	0.047	0.019	0.009	0.108	-0.011	0.343	-0.334	1.000			
Subject	0.163	0.018	0.030	-0.020	0.194	0.022	-0.030	-0.029	0.026	1.000		
SATISFAC	-0.043	-0.060	0.024	-0.003	0.017	0.033	0.013	-0.039	0.038	0.006	1.000	
RETENT	-0.012	-0.026	0.069	0.017	-0.004	0.023	0.010	0.000	0.083	-0.012	0.338	1.000

Matrix 2. Correlation Matrix for Science Teachers

	SL_DIS	SL_LEP	PD_DIS	PD_LEP	GENDER	MAJORITY	HIDEGR	NEWTCH	EARNSCH	SATISFAC	RETENT
SL_DIS	1.000										
SL_LEP	0.188	1.000									
PD_DIS	0.102	0.016	1.000								
PD_LEP	0.047	0.250	0.268	1.000							
GENDER	-0.028	-0.017	-0.009	-0.052	1.000						
MAJORITY	-0.039	-0.050	-0.013	-0.056	0.042	1.000					
HIDEGR	-0.002	-0.034	-0.001	-0.054	-0.003	0.004	1.000				
NEWTCH	-0.008	0.023	0.012	0.050	-0.018	-0.034	-0.240	1.000			
EARNSCH	-0.008	0.035	0.031	-0.007	0.129	0.005	0.353	-0.334	1.000		
SATISFAC	-0.053	-0.080	0.028	0.016	0.030	0.022	0.030	-0.053	0.037	1.000	
RETENT	-0.006	-0.020	0.100	0.018	0.010	0.034	0.046	-0.024	0.103	0.305	1.000

Matrix 3. Correlation Matrix for Mathematics Teachers

	SL_DIS	SL_LEP	PD_DIS	PD_LEP	GENDER	MAJORITY	HIDEGR	NEWTCH	EARNSCH	SATISFAC	RETENT
SL_DIS	1.000										
SL_LEP	0.152	1.000									
PD_DIS	0.120	0.008	1.000								
PD_LEP	0.003	0.260	0.258	1.000							
GENDER	0.036	0.024	-0.015	-0.021	1.000						
MAJORITY	-0.015	-0.074	-0.043	-0.064	0.009	1.000					
HIDEGR	0.005	-0.003	0.008	-0.034	0.008	-0.001	1.000				
NEWTCH	0.044	0.031	0.008	0.037	-0.001	-0.001	-0.276	1.000			
EARNSCH	-0.010	0.045	0.020	0.020	0.076	-0.035	0.354	-0.346	1.000		
SATISFAC	-0.030	-0.049	0.022	-0.019	-0.001	0.038	0.006	-0.035	0.053	1.000	
RETENT	0.001	-0.039	0.049	0.033	-0.019	0.022	0.019	0.013	0.088	0.371	1.000

Matrix 4. Correlation Matrix for Technology Teachers

	SL_DIS	SL_LEP	PD_DIS	PD_LEP	GENDER	MAJORITY	HIDEGR	NEWTCH	EARNSCH	SATISFAC	RETENT
SL_DIS	1.000										
SL_LEP	0.270	1.000									
PD_DIS	0.076	0.029	1.000								
PD_LEP	0.043	0.276	0.273	1.000							
GENDER	-0.061	-0.082	-0.031	-0.068	1.000						
MAJORITY	0.022	-0.060	-0.050	-0.086	0.073	1.000					
HIDEGR	0.100	0.091	0.021	0.043	-0.082	-0.017	1.000				
NEWTCH	-0.084	-0.020	0.021	-0.003	-0.015	-0.048	-0.209	1.000			
EARNSCH	0.144	0.086	-0.033	0.029	0.160	0.036	0.286	-0.282	1.000		
SATISFAC	-0.077	-0.034	0.012	0.009	0.015	0.049	-0.006	0.008	-0.028	1.000	
RETENT	-0.062	0.007	0.050	-0.075	-0.029	-0.012	-0.160	0.037	-0.025	0.311	1.000

Matrix 5. Correlation Matrix for All Other Teachers

	SL_DIS	SL_LEP	PD_DIS	PD_LEP	GENDER	MAJORITY	HIDEGR	NEWTCH	EARNSCH	SATISFAC	RETENT
SL_DIS	1.000										
SL_LEP	0.163	1.000									
PD_DIS	0.140	-0.027	1.000								
PD_LEP	-0.025	0.224	0.162	1.000							
GENDER	0.060	0.042	-0.023	-0.019	1.000						
MAJORITY	-0.003	-0.021	-0.038	-0.047	-0.012	1.000					
HIDEGR	0.051	0.008	0.024	0.001	-0.036	0.000	1.000				
NEWTCH	-0.028	-0.012	-0.012	0.009	0.013	-0.006	-0.226	1.000			
EARNSCH	0.084	0.064	0.022	0.030	0.082	-0.007	0.343	-0.321	1.000		
SATISFAC	-0.011	-0.034	0.031	0.007	-0.010	0.021	0.003	-0.012	0.025	1.000	
RETENT	-0.018	-0.033	0.049	0.014	-0.033	0.003	-0.008	0.030	0.053	0.321	1.000

Appendix C

Logistic Regression Models

Model 1: STEM Teacher Satisfaction

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.405e+00	2.756e-01	5.098	2.34e-06	*
SL_DIS	2.860e-04	3.972e-03	0.072	0.9428	
SL_LEP	-1.032e-02	4.515e-03	-2.286	0.0250	*
PD_DIS	2.352e-01	1.582e-01	1.487	0.1412	
PD_LEP	1.240e-02	2.402e-01	0.052	0.9590	
GENDER	1.389e-01	1.409e-01	0.986	0.3273	
MAJORITY	3.927e-01	2.837e-01	1.384	0.1702	
HIDEGR	-2.035e-02	1.487e-01	-0.137	0.8916	
NEWTCH	-3.213e-01	1.726e-01	-1.862	0.0664	
EARNSCH	6.157e-06	4.292e-06	1.435	0.1554	

* Significant at .05 level

Model 2: Science Teacher Satisfaction

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.476e+00	5.284e-01	2.793	0.00657	*
SL_DIS	2.936e-03	6.321e-03	0.464	0.64360	
SL_LEP	-1.564e-02	5.980e-03	-2.615	0.01070	*
PD_DIS	2.243e-01	2.447e-01	0.916	0.36227	
PD_LEP	3.159e-01	2.883e-01	1.096	0.27649	
GENDER	1.418e-01	2.279e-01	0.622	0.53568	
MAJORITY	3.481e-01	4.583e-01	0.760	0.44981	
HIDEGR	4.769e-03	2.444e-01	0.020	0.98449	
NEWTCH	-3.967e-01	3.063e-01	-1.295	0.19905	
EARNSCH	4.443e-06	6.439e-06	0.690	0.49228	

* Significant at .05 level

Model 3: Mathematics Teacher Satisfaction

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.249e+00	4.372e-01	2.856	0.0055	*
SL_DIS	5.672e-03	7.746e-03	0.732	0.4663	
SL_LEP	-7.435e-03	7.362e-03	-1.010	0.3156	
PD_DIS	1.818e-01	2.754e-01	0.660	0.5111	
PD_LEP	-2.732e-01	3.185e-01	-0.858	0.3936	
GENDER	1.487e-01	2.078e-01	0.715	0.4764	
MAJORITY	4.094e-01	3.874e-01	1.057	0.2939	
HIDEGR	-1.202e-01	2.023e-01	-0.594	0.5540	
NEWTCH	-3.418e-01	2.214e-01	-1.544	0.1267	
EARNSCH	1.075e-05	6.344e-06	1.694	0.0943	

* Significant at .05 level

Model 4: Technology Teacher Satisfaction

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.351e+00	1.009e+00	1.339	0.185
SL_DIS	-5.004e-03	8.622e-03	-0.580	0.563
SL_LEP	-6.572e-03	1.314e-02	-0.500	0.618
PD_DIS	4.247e-01	4.316e-01	0.984	0.328
PD_LEP	6.931e-01	7.062e-01	0.981	0.329
GENDER	1.542e-01	5.599e-01	0.275	0.784
MAJORITY	6.086e-01	9.159e-01	0.664	0.508
HIDEGR	1.407e-01	4.894e-01	0.288	0.774
NEWTCH	3.923e-02	6.940e-01	0.057	0.955
EARNSCH	-2.158e-06	1.514e-05	-0.143	0.887

* Significant at .05 level

Model 5: All Other Teacher Satisfaction

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.606e+00	1.778e-01	9.032	9.37e-14	*
SL_DIS	1.989e-03	2.388e-03	0.833	0.40743	
SL_LEP	-4.591e-03	1.903e-03	-2.413	0.01817	*
PD_DIS	2.638e-01	1.044e-01	2.528	0.01349	*
PD_LEP	3.611e-02	1.364e-01	0.265	0.79187	
GENDER	-1.454e-01	9.137e-02	-1.591	0.11561	
MAJORITY	2.752e-01	1.596e-01	1.724	0.08865	
HIDEGR	-1.327e-01	1.051e-01	-1.262	0.21079	
NEWTCH	-1.291e-01	1.436e-01	-0.899	0.37144	
EARNSCH	8.086e-06	2.803e-06	2.885	0.00506	*

* Significant at .05 level

Model 6: STEM Teacher Intent to Remain

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.168e-01	3.619e-01	0.323	0.747792	
SL_DIS	-3.808e-04	5.198e-03	-0.073	0.941782	
SL_LEP	-8.314e-03	4.530e-03	-1.835	0.070264	
PD_DIS	4.180e-01	1.601e-01	2.610	0.010841	*
PD_LEP	-6.480e-03	1.970e-01	-0.033	0.973842	
GENDER	1.671e-02	1.242e-01	0.135	0.893324	
MAJORITY	2.874e-01	2.601e-01	1.105	0.272692	
HIDEGR	5.090e-02	1.603e-01	0.318	0.751611	
NEWTCH	2.579e-01	2.040e-01	1.264	0.209827	
EARNSCH	2.154e-05	5.363e-06	4.017	0.000135	*

* Significant at .05 level

Model 7: Science Teacher Intent to Remain

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-2.152e-01	6.774e-01	-0.318	0.7516	
SL_DIS	4.405e-03	8.512e-03	0.518	0.6063	
SL_LEP	-1.199e-02	7.237e-03	-1.657	0.1015	
PD_DIS	5.772e-01	2.569e-01	2.247	0.0275	*
PD_LEP	5.493e-02	3.316e-01	0.166	0.8689	
GENDER	-5.136e-02	2.204e-01	-0.233	0.8164	
MAJORITY	3.963e-01	4.289e-01	0.924	0.3584	
HIDEGR	2.700e-01	2.369e-01	1.140	0.2578	
NEWTCH	1.636e-01	3.131e-01	0.523	0.6028	
EARNSCH	1.944e-05	8.738e-06	2.224	0.0290	*

* Significant at .05 level

Model 8: Mathematics Teacher Intent to Remain

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.564e-01	4.792e-01	0.326	0.74495	
SL_DIS	-2.753e-03	1.073e-02	-0.257	0.79811	
SL_LEP	-7.203e-03	7.421e-03	-0.971	0.33473	
PD_DIS	2.005e-01	2.625e-01	0.764	0.44732	
PD_LEP	1.918e-02	3.165e-01	0.061	0.95183	
GENDER	2.954e-02	2.079e-01	0.142	0.88737	
MAJORITY	2.693e-01	3.436e-01	0.784	0.43547	
HIDEGR	-8.986e-03	2.186e-01	-0.041	0.96732	
NEWTCH	4.502e-01	2.702e-01	1.666	0.09971	
EARNSCH	2.458e-05	7.382e-06	3.329	0.00133	*

* Significant at .05 level

Model 9: Technology Teacher Intent to Remain

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.215e+00	2.955e+00	0.750	0.4558	
SL_DIS	-9.397e-03	1.518e-02	-0.619	0.5378	
SL_LEP	1.765e-02	2.004e-02	0.881	0.3812	
PD_DIS	9.124e-01	5.282e-01	1.727	0.0881	
PD_LEP	-7.254e-01	6.491e-01	-1.118	0.2672	
GENDER	-1.350e-01	5.930e-01	-0.228	0.8205	
MAJORITY	-1.326e-01	2.975e+00	-0.045	0.9646	
HIDEGR	-9.168e-01	6.304e-01	-1.454	0.1499	
NEWTCH	-7.576e-01	9.172e-01	-0.826	0.4113	
EARNSCH	8.897e-06	1.146e-05	0.776	0.4400	

* Significant at .05 level

Model 10: All Other Teacher Intent to Remain

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.019e+00	1.942e-01	5.246	1.30e-06	*
SL_DIS	-4.124e-03	2.652e-03	-1.555	0.1239	
SL_LEP	-1.963e-03	2.698e-03	-0.728	0.4690	
PD_DIS	2.533e-01	1.160e-01	2.182	0.0321	*
PD_LEP	-1.152e-01	1.336e-01	-0.862	0.3914	
GENDER	-2.747e-01	1.363e-01	-2.015	0.0473	*
MAJORITY	1.007e-01	1.698e-01	0.593	0.5551	
HIDEGR	-2.115e-01	1.193e-01	-1.774	0.0800	
NEWTCH	4.166e-01	1.787e-01	2.332	0.0223	*
EARNSCH	2.019e-05	2.716e-06	7.434	1.16e-10	*

* Significant at .05 level